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HISTOLOGY AND CYTOLOGY OF SUGAR CANE MOSAIC[1]

MELVILLE T. COOK

The various mosaic diseases of plants have been extremely puzzling from the time they were first recognized as diseases. Although they have been the subjects of study by some of the leading scientists of the world, the causes are as yet not definitely known. Many theories have been advanced as to the causes of which the following are some of the most important:—(1) bacterial, (2) virus, (3) physiological, (4) enzymatic, (5) protozoan.

All students of the mosaic diseases are familiar with these theories and therefore, it is not necessary to discuss them further than to say that the "virus" and "protozoan" theories are the most prominent at this time. Probably the most important facts that we have learned about these diseases are (1) that they can be transmitted from generation to generation through vegetative parts, (2) that some of them may be transmitted by means of insects, (3) that some of them will attack plants other than the economic crops in which we are interested, (4) that they may be present but not visible in some plants.

The studies recorded in this paper were undertaken (1) for the purpose of studying histological and cytological differences between diseased and healthy plants and (2) for the purpose of gaining some light if possible as to the cause of this particular form of mosaic. Before taking up the results of these studies it is desirable to review the literature bearing directly on this phase of the subject, but since this paper deals only with the histological and cytological characters of mosaic sugar cane as compared with apparently healthy cane we will not refer to any literature other than that which has a direct bearing on these phases of the subject. It will be readily seen that the most extensive studies on these phases of the mosaic disease have been made on tobacco which is a dicotyledonous plant and therefore, not strictly comparable to the sugar cane which is a monocotyledonous plant.

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HISTORICAL

The first histological studies of mosaic were made by Köning (7) on tobacco but very little difference was noted between healthy and diseased tobacco other than that in the latter the chloroplasts were disorganized and the cell walls disintegrating.

A brief reference to this phase of the subject was made by Woods (19) in his studies on tobacco mosaic, who noted the abnormal condition of the light-colored areas and said that—

> "This difference consists in the fact that in the badly diseased plants the palisade parenchyma of the light-colored areas is not developed at all. All the tissue between the upper and lower epidermis consists of a spongy or respiratory parenchyma rather more closely packed than normal. In moderately diseased plants the palisade parenchyma of the light area is greatly modified. Normally the palisade parenchyma cells of a healthy plant are from four to six times as long as broad. In a moderately diseased plant, however, the cells are nearly as broad as they are long, or at most, not more than twice as long as broad. As a rule, the modified cells of the leaf passes abruptly into the normal cells of the green area."

Heintzel (5) does not refer to any variation in palisade cells but does note difference in the intercellular spaces in both palisade and parenchyma. He also notes that the chloroplasts were congregated irregularly in small groups.

Bouygues (2) reports an absence of the epidermis and a disappearance of the cell contents in the old spots.

The first extensive studies on this phase of the disease was made by Iwanowski (6) who also worked on tobacco. Although the cane and tobacco mosaics are probably due to different causes his studies are of special importance at this time. His results bearing on these studies may be summarized as follows:

(1) The infectious principle is not dissolved in the juice.

(2) Calcium oxalate crystals is characteristic of diseased plants.

(3) Transition zone between light and dark green areas consists of only 2 or 3 more rows of cells.

(4) Cross section of green part of a leaf shows the tissues well differentiated.

(5) Pale part is thin; pallisade modified; crystals prominent; no necrosis.

(6) Contents show lack of chloroplasts which are not regularly distributed. (In live cells the chloroplasts are swollen.)

(7) Films seen in the cells.

(8) Sometimes cells have granulations resembling bacteria.

(9) Nuclei normal or magnified and granular. Plasma bodies near them.

(10) Finds bacteria.

(11) Argues that this must be bacteria and not amoeba because amoeba can not go through a filter.

Westerdijk (18) reports that there was no microscopic difference worthy of mention other than that the chloroplasts were smaller and yellowish and that there was but little starch.

The next studies on this phase of the subject were made on the tomato mosaic by Melchers (14) who found that the light green or yellow areas were thinner than the dark green areas and that this was due to a shortening of the pallisade cells. The chloroplasts in the yellow areas were somewhat fewer in number and a pale yellowish green color.

Chapman (3) in his studies on mosaic of tobacco very generally agrees with Woods, but he found that occasionally the parenchyma of the dark green areas was more compact than in the normal plant. He also noted that the dark green areas contained some of the infecting agent. He found no histological differences in the roots and leaves but says that—

> "The causal agent * * * is without question present *in all parts of the plant.*"

Artschwager (1) in his studies on the leaf roll of potato found certain changes in the vascular tissues but did not always find "a definite relation between external symptoms and internal changes." However, he reports an accumulation of starch in the diseased leaves. Histological studies on the leaf roll of the potato have been made by a number of European workers but since these studies do not appear to parallel the studies on the sugar cane mosaic, we will omit a discussion of them.

The first studies on the histology of mosaic sugar cane was made by Matz (11) who noted the following: (1) "distinct, single, spherical, darkly colored and densely protoplasmic bodies" in the parenchyma and collenchyma cells of the cankered stem tissues. They resembled "spore bodies" but were soluble in alcohol and he afterwards found them in non-yellow striped cane. (2) As a result of comparative studies on healthy and diseased stems (upper nodes) and leaves he says:

> "It seems that a foreign plasmodium-like substance is apparently present in the cells of the yellow-striped cane leaf and stem tissue."
>
> "Microscopic sections of the discolored areas in yellow-striped cane stalks

show that some parenchyma cells are full of a more or less hardened or compact but finely granulated and slightly browned plasma.''

(3) He also says:

> ''From a study of the internal structure of cankered cane it is clear that actual deterioration and breaking down of cells in the interior of cane in an advanced stage of the yellow-stripe disease takes place. This effect is due to no other causes than to the destructive action of the infective substance of yellow-stripe disease, as there is apparently no connection between these interior sick cells and outer outside mechanical or organizd agencies. Furthermore, this substance resembling a *Plasmodium,* in some of the interior cells was found to be constantly associated with yellow-striped cane in an advanced stage of disease.''

A little later Kunkel (8) made some most interesting studies on the mosaic disease of corn in which he describes intracellular bodies which he finds in the diseased but not in the healthy plants. These bodies are variable in shape, irregular and amoeboid but never spherical. They are closely associated with the host nucleus which becomes enlarged. This work is of special interest to us because the mosaic of the corn is supposed by some workers to be the same as the mosaic of cane. If not identical they are probably closely related.

In commenting on Matz paper he says:

> ''The writer is able to confirm the observations of Matz as regards the occurrence in diseased cane tissue of cells filled with a hardened, granular, slightly brown substance. Such cells are constantly associated with the disease in mature tissues. This substance, however, does not resemble any of the plasmodia with which the writer is acquainted. It does not stain like protoplasm, does not show a protoplasmic structure, is not vacuolate, does not contain any structure that could be taken for a nucleus, and is not plastic. When crushed, this substance breaks up into irregular-shaped angular masses which keep their form indefinitely and do not dissolve in water.''

He also says that—

> ''Cells filled with exactly the same kind of granular material are also present in the stalk tissues of corn suffering from mosaic.''

In his discussion Kunkel says:

> ''While it is not possible at the present time to prove that the bodies are living parasites, there is considerable evidence in favor of this view. They grow, show a structure like that of protoplasm, stain like protoplasm, and tend to be amoeboid in shape. It seems hardly probable that waste products accumulating in diseased cells or the products of protoplasmic degeneration would show these characteristics and would always be so closely associated with the host cell nucleus.''

In a latter paper Kunkel **(9)** reported the finding of amoeboid bodies in mosaic diseased plants of *Hippeastrum equestre.*

In a more recent work on tobacco Palm **(15)** described "amoebiform corpuscles" which he apparently considers similar to the bodies described by Kunkel in corn mosaic. Kunkel believes that these "amoebiform corpuscles" of Palm and the "Plasmaanhanfungen" of Iwanowski to be the same as the "intracellular bodies" which he found in corn, tobacco and other plants. Palm also reports the finding of numerous extremely small granules which he believes to be alive and the same as the bodies which Iwanowski described as bacteria. He has given these bodies the name of *Strongyloplasma iwanowskii.*

In a second paper on mosaic of sugar cane, Matz **(12)** reviews the works of Iwanowski, Kunkel and Palm in the light of his own studies and further states that—

> "In the diseased tissue the chloroplasts are few and are evidently misshaped and broken up. In stained sections they look like mere ink spots, one or two in a cell. This destruction of chloroplasts is a symptom of sugar-cane mosaic and it fixes the seat of the disease more definitely. Apparently the cell walls and other cell contents are not affected, but the chloroplasts are gradually destroyed."

He furthermore says—

> "It was seen that the breaking up of the chloroplasts begins with a reduction in their size. The chloroplasts in the healthy or green parts of the same leaf were normal in their size and numbers, while in the discolored or pale-green stripes chloroplasts in all stages of reduction were noted."

The next paper bearing directly on the subject was also by Kunkel **(10)** who found intracellular bodies in Chinese cabbage, *Brassica pekinensis* (Lour) Gagn., sugar cane, *Saccharum officinarum* L., and in tobacco, *Nicotiana tabacum* L. In discussing these bodies he says:

> "While no attempt will here be made to fully describe the bodies found in the mosaic tissues of Chinese cabbage, sugar cane, and tobacco, a brief statement regarding them may be of interest. In each of these plants the amoeboid bodies are quite similar to, but somewhat different from the bodies associated with the mosaic in corn and Hippeastrum. In the leaves of the Chinese cabbage they reach about the same size that they do in the leaves of Hippeastrum. They are usually not in contact with the host nucleus and may occupy any part of the cell. They frequently have a number of chloroplasts clustered around them. In structure and in staining reaction they are similar to the bodies of corn mosaic. The bodies associated with the sugar-cane mosaic tend to stain more deeply than do those in any of the other plants studied, and are more irregular in shape. * * * Because of the fact that the older tissues of the sugar-cane plant be-

come very hard they are not suitable for cytological studies. Satisfactory sections showing the bodies of cane mosaic have been made from stalk tissues only. The best sections were obtained from tissues a short distance back of the growing point."

"After having found intracellular bodies associated with mosaic in corn, Hippeastrum, Chinese cabbage, and sugar cane, a study was made of stained sections of healthy and mosaic tobacco leaves. In some of the sections of mosaic leaves, bodies similar to those described in corn and Hippeastrum may plainly be seen. In morphology of the host cell, they are much like the bodies found in the cells of the other plants."

At about this time extensive histological studies were made by Dickson **(4)** on a number of species of plants infected with mosaic. In the case of tobacco he found diseased leaves about two-thirds as thick as the normal leaves; the palisade parenchyma cells of diseased leaves shorter than those of normal leaves and in the case of severely infected leaves these cells were cuboidal or isodiametric. In some cases there were two layers of short palisade cells in severely diseased leaves. The cells in the spongy mesophyll of diseased areas were smaller than those in the dark green areas or in normal leaves and the total area of intercellular spaces in healthy parts 50 per cent greater than in diseased parts. The trichomes were more abundant in the light than in the dark-green areas. The number of chloroplasts in the light-green areas was much less than in the dark-green areas in healthy leaves and retrogressive changes were frequent. He also "observed occasional instances in severely diseased specimens where the nuclei were irregular in shape, being subspherical to angular, or considerably hypertrophied."

He also found a very similar condition in the tomato, petunia, potato, black henbane, pepper, sweet pea, kidney bean and broad bean.

A little later McKinney, Eckerson and Webb **(13)** published the results of what may be a similar disease of wheat. They found intracellular bodies in rosette and mottled wheat but did not find similar bodies in healthy plants. In commenting on the findings in this paper it should be borne in mind that these diseases of wheat may be carried in the soil which is not true of the mosaics. The authors of this paper find that these bodies are usually single; that they are variable in size and that they increase in size with the age of the host cell; that the relation to the nucleus is variable, occasionally or completely surrounding it; that they appear to be surrounded by a membrane; that the infected cells are not different from the healthy cells and that the host nuclei show little or no abnormalities.

Smith **(17)** made a study of the potato mosaic and noted amoeba-like bodies in the yellow chlorotic areas. These bodies "tended towards pear-shaped or round." "These corpuscles seemed to be possessed of a definite wall and had in addition one or more very clearly defined vacuoles." "In many cases they were closely associated with the cell nucleus." He failed to find nuclei in these bodies and the chloroplasts were much reduced in number. The cell walls were frequently ruptured and there was a general disintegration of tissue in the light green or yellow areas and the "nuclei themselves are in a state of complete degeneration." He believes the intracellular bodies to be "degenerate products of the host cells."

The last paper on the subject is by Rawlins and Johnson **(16)** who made cytological studies of tobacco and who found two types of bodies in mosaic tissues, one type being very generally associated with the nuclei.

INVESTIGATIONAL

The studies on which this paper is based have been directed primarily along lines suggested by the researches of Iwanowski **(6)**, Palm **(15)** and Kunkel **(8, 9, 10)**. The killing fluid most generally used was weak Fleming but Carnoy's fluid and several mixtures of picric and acetic acids both with and without corrosive sublimate were also tried. Weak Flemming fluid proved to be most satisfactory. The most satisfactory stain was found to be Haidenhain's Iron-alum-Haematoxylon, care being taken not to destain too much. The bodies which are associated with the mosaic disease showed to the best advantage when the nuclei of the cane were stained too deep for satisfactory study. A number of matrix stains such as Orange G and Eosin were used but were not necessary to good results. Safranin and Gentian Violet were found to be much less satisfactory than the Iron-alum-Haematoxylon. Carmin stains were tried but proved unsatisfactory.

These studies have to do with both leaves and stems. A few studies were made on the roots, but since no difference between roots from healthy and diseased plants were noted, they will be omitted. In making the studies of diseased leaves, sections were cut from both dark and light green or yellowish spots; and from cane of the same variety and about the same age, supposed to be healthy. In the study of the diseased stems, buds and roots, preparations were also made from corresponding parts of supposedly healthy canes of the same variety and age.

In order to aid in the discussion, we will present a somewhat digramatic drawing (Fig. 1) of a cross section of a normal cane leaf to be used as a map in our further discussion. In this drawing it will be noted that the leaf is made up of a mesophyll consisting of large and small cells, the former being near the upper surface and usually without chlorophyll; there is no pallisade as in most plants; the mesophyll is supported by fibro-vascular bundles of various sizes, and the larger ones extending almost from epidermis to epidermis; the smaller ones lying near the lower surface; the upper epidermal cells are slightly larger than the lower and the upper cuticle slightly thicker; the stomata are found on both surfaces. The large fibro-vascular bundles consist of xylem cells surrounded by sclerenchyma cells which are in turn surrounded by a single layer of sheath cells. In the smaller bundles the sclerenchyma cells are reduced in number and may be absent. The sheath cells are more or less tubular; in cross section they appear more or less circular and in the longitudinal section rectangular. The nuclei are readily seen in the irregular parenchyma unless concealed by chloroplasts. They are usually more prominent in the large parenchyma and epidermal cells. They are more prominent in longitudinal than in cross sections of the sheath cells, because the diameter of the cells is so narrow that practically every section through a cell shows the nucleus while the length of the cells is great enough that many sections of a cell do not pass through the nucleus. The chloroplasts are larger in the sheath than in the other mesophyll cells and the markings more regular and distinct. There is also much less chlorophyll in the large than in the small cells of the mesophyll.

It is well known that the leaf symptoms of mosaic are most conspicuous on actively growing cane and on the new leaves. In a mosaic cane bearing fifteen or twenty leaves the symptoms on the oldest leaves have almost entirely disappeared. This has been observed repeatedly on canes that had been under observation from time of germination. A study of the cells of these leaves shows that the chloroplasts are always more numerous in the dark-green than in the light areas. Therefore, it appears that in the case of the light-green areas the formation of chloroplasts is inhibited but that with the exposure to sunlight this inhibition is gradually overcome.

Measurements of a number of specimens showed that the light-colored areas were always slightly thinner than the dark-green areas of the same leaf. This difference is so slight in most cases as not to be perceptible except as the result of careful measurements. Similar differences in thickness have been noted by Iwanowski and Woods on tobacco and by Melchers on tomatoes. There was no perceptible difference in form, size, compactness of cells such as have been mentioned by Woods, Heintzel, Bouygues, Iwanowski and Chapman in tobacco and by Melchers in tomato. However, it should be remembered that tobacco and tomato are both dicotyledonous while cane is monocotyledonous and that the normal leaf structures are quite different in most species of these two great groups of plants. Therefore, the comparisons of structure of the one with the other are not altogether pertinent in this discussion.

There was no great variation in size and character of cells in mosaic cane as compared with healthy canes such as have been noted by Woods Heintzel, Bouygues, Iwanowski and Chapman in tobacco, by Melchers in tomato, and by Artschwager in potato. However, there was a very slight reduction in size of cells in mosaic canes, especially in the sheath cells of the fibro-vascular bundles.

The intracellular bodies which have been described by Kunkel could be found by careful search (Figs. 2–22, 35, 36) but they were not abundant or conspicuous. They were found in the white areas of the leaves and near the growing points in the stems of the canes and sometimes in other places, but never in healthy canes and never in the roots of diseased canes. They were more readily found in young rapidly growing plants than in old plants. They were not always found in severely diseased plants It is doubtful if they would have attracted the attention of the writer if he had not been looking for them.

These bodies correspond quite well to those described by Kunkel. They appear to be protoplasmic and usually have a more or less definite outline. They were closely associated with the nuclei and are irregular in size and character. In most cases the bodies were in direct contact with the nuclei, but in a few cases they were slightly removed (Fig. 35). Although irregular in shape, they were seldom amoeboid (Figs. 15, 16). In some cases the plasmodial body was dense and in others very delicate and staining very slightly. In some cases these bodies appeared to be surrounded by delicate membranes while in others no such membranes could be detected. This condition has been noted by Kunkel. In some cases peculiar bodies (Fig. 24) were found in cells in which their nucleus could not be seen, but it was impossible to determine if they were or were not the same as those associated with the nuclei in other cells. No nuclei could be detected in any of the bodies under observation. In no case was the veil-like structure described by Kunkel observed.

The variations in appearance of the host nuclei (Figs. 25–39, 55–58) were quite noticeable. In some cases there was no visible change in the character of the nuclei while in others the nuclei were very much enlarged as has been previously noted by Kunkel. In some cases there were two or more nuclei in a single cell but this was also true in tissues from plants that were apparently healthy. Two or more nuclei were much more frequent in the cells of the stems than in the cells of the leaves. In some few cases a tendency to disintegration (Figs. 23, 37) was noted but the writer is very doubtful if this had any relation to the disease. However, the greatest abnormalities in the nuclei were in the white or yellow areas of the leaves. The nuclei in these areas were usually very large and very irregular in shape as compared with nuclei in the dark green areas and in normal leaves of the corresponding age and development. In these green areas and in normal plants the nuclei were comparatively small and spherical in form. A very puzzling feature of this study is that the writer found very few of the intracellular bodies in those cells which showed the greatest abnormalities (Figs. 35, 36). Many of the abnormal nuclei were very much elongated and resembled flagellata (Figs. 28–34) but there was no difficulty in determining their true character. These elongated nuclei must not be confused with the elongated nuclei of the vascular tissues; they are in the parenchyma cells and the size and form has all the appearances of being the results of stimulation. In several cases there was evidence that the nucleus had been destroyed and that the plasmodial bodies (Fig. 24) alone remained in the cells but it was difficult to say definitely whether these bodies were or were not distinct from the normal protoplasm of the cells. The enlargement of the nuclei of host cells in the case of diseases caused by fungi and bacteria has been recorded by a considerable number of workers It is also very generally conceded that host cells which are not in direct contact with the parasite may undergo modifications. The modifications may be due indirectly to the parasite, through the direct action of its enzymes on the host cell. Therefore it is possible that the modifications of the host nuclei in the mosaic sugar-cane cells are due to enzymes. This may explain the fact that intracellular bodies were not found more frequently associated with the abnormally developed cells. It is well known that cells in host plants which are not in contact with the parasitic organisms, such as nematodes and *Plasmodiophora brassicae* develope abnormal characters. In this connection it is interesting to recall that the enzyme theory was advanced by Heintzel in 1900 and was further elaborated by Woods in 1902.

Another interesting phase of this study was brought out by a careful study of nuclei in the white areas of all the leaves of a diseased plant (Fig. 39 *a–j*). In these cases the nuclei in the outer leaves are very nearly normal while those in the inner leaves are abnormal. It appears that the nuclei tend to become normal with age and exposure to light.

The mitosis of nuclei was observed several times and was normal in every case. No intracellular bodies were seen in cells in which the nuclei were in process of division.

The variation in character of the chloroplasts (Figs. 40–50, 55–58), in mosaic and healthy tissues was fully as marked as the variations in character of the nuclei. In considering th's phase of the subject the reader must remember that there are two very distinct types of chloroplasts; those found in the sheath cells and those found in the parenchyma tissues which have already been referred to (see page 12.) The chloroplasts in the white or yellow areas were fewer in number and smaller than in the green areas. In making these comparisons it is necessary to compare with the corresponding tissues, since the chloroplasts in the sheath cells are normally larger and have more definite markings than those in the mesophyll cells. Similar differences in size and number of chloroplasts in cells from white and green areas have been noted by Koning, Iwanowski, Melchers, Matz and others in their studies on mosaic of tobacco, tomato and cane.

The chloroplasts in normal sheath cells are spherical or nearly so and are usually near the cell wall, leaving an open space in the center of the cell (Fig 40) In the case of diseased cells they are fewer in number, very much smaller and are grouped near the wall in one part of the cell (Fig 41, 43). A close examination of these chloroplasts shows that those that are normal are covered with an anastomosing net work of ridges (Fig. 49 *a*). Those from diseased cells have these ridges very much reduced (Fig 49 *b*). These points can be readily seen in lightly stained chloroplasts.

The chloroplasts in the normal mesophyll cells (Figs. 44, 46 *a*, 47 *a*) next to the sheath cells are somewhat smaller than the chloroplasts in the sheath cells. They are spherical or nearly so and have no regular distribution. In the corresponding cells of a diseased plant they are very much smaller and usually fewer in number (Figs. 45, 46 *b*, 47 *b*). The markings on these chloroplasts are much less distinct than on those in the sheath cells.

The small chloroplasts of the mosaic cells are usually spoken of as having undergone a process of degeneration. The writer has studied the chloroplasts in the very young unrolled leaves and is satisfied that these chloroplasts are undeveloped rather than disintegrated. They have never reached normal development. Furthermore a study in a series of leaves from those just unrolling to the outermost on a plant shows that the chloroplasts of both normal and mosaic cells (figs. 50 *a–i*) increase in size after being exposed to light. These changes which are apparently due to age or light are so pronounced that there is very little difference in size of chloroplasts in the old leaves of a diseased plant and the chloroplasts in a leaf of the same age from a healthy plant. The writer is very doubtful if disintegration ever occurs in the case of primary infection (*i. e.*, infection from the seed).

Matz (11) called attention to the formation of internal cavities as a result of the collapse of parenchyma cells. These lesions have been referred to later by Kunkel (8) as symptoms of the mosaic disease. These lesions are without doubt common to mosaic sugar cane, but are also found in cane with other diseases. Our studies indicate that these lesions may start very early in the growth of the cane, especially if the plant is severely infected. The writer found the early stages of these lesions (Fig. 51–54) starting by a gradual disorganizing of the walls of the xylem cells of the fibro-vascular bundles and of the parenchyma cells in contact with the bundles in both stems and leaves. This disorganization of the cell walls was not preceded by a thickening of the walls as described by Kunkel The disorganization of cell walls by the action of enzymes produced by fungi and bacteria is well known in the case of many plant diseases, and the disorganization of the cell wall in this case is certainly analogous if not homologous to the disorganization of cell walls in a number of other well-known plant diseases. The behavior of these cells before the disintegration of the cell walls was by no means uniform. In most cases they were filled with a dense mass of deep-staining protoplasm (Fig. 51 *a*), but in other cases the protoplasm was not dense (Fig. 51 *b*). In many cases there were small deep staining bodies scattered through the protoplasm mass (Fig. 51 *b*). With the disintegration of the cell walls (Figs. 52, 53), these masses of protoplasm became very prominent, like numerous islands floating in a clear liquid. Numerous deep staining bodies were observed scattered among these islands. They stained exactly the same as nucleoli set free by the disintegrating protoplasm. However similar bodies were observed in section of normal tissues. The fate of this disintegrating protoplasm was not determined. None of the intracellular bodies were found in it. This disintegration of cell walls was observed in the fibro-vascular bundles in both stem and leaf. The fact that it was always associated with the fibro-vascular bundles may be of some significance.

Matz has called attention to the presence of a "granular plasma material" in the parenchyma cells. Material which is probably the same as that noted by Matz has been observed by the writer. This material is frequently found in canes in advanced stages of the disease, especially old canes, but it is also found in canes with other diseases and in old canes that are apparently normal. Therefore, it is doubtful if it can be looked upon as important. However, the writer frequently noted a peculiar finely granular or protoplasmic material in cells, but it was impossible to determine its significance.

The photosynthetic action of diseased plants was very much disturbed. Studies were made from leaves collected before daylight and from corersponding leaves collected about 2 P. M. In the case of healthy leaves the behavior was normal; there was an abundance of starch at 2 P. M. and very little at 5 P. M. In the case of diseased leaves there was much less starch formation than in healthy leaves. A more extensive report on this phase of the subject will be given in a later paper.

SUMMARY

1. The symptoms of mosaic are more conspicuous on actively growing than on slow growing plants; and on the new than on the old leaves of a diseased plant.

2. The light areas of a diseased leaf are slightly thinner than the green areas.

3. The green areas correspond in every way to the leaves from healthy plants of the same age and variety.

4. The cells in the light area of a diseased leaf are slightly less in size than those in the green areas.

5. Intracellular bodies were difficult to find but corresponded quite well with those reported by Kunkel.

6. The host nuclei were usually very much enlarged in the diseased tissues, especially in the tissues of the leaves. They were frequently very irregular in form and it was very difficult to find intracellular bodies associated with them.

7. The chloroplasts were smaller and fewer in number in the mosaic than in the healthy tissues.

8. The internal cavities in both stems and leaves start with a disintegration of the cell walls.

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EXPLANATIONS OF PLATES

FIG. 1.—Cross section of normal cane leaf. Semi-diagrammatic. (*a*) Upper epidermis. (*b*) Lower epidermis. (*c*) Cuticle. (*d*) Stomata. (*e*) Large parenchyma cells, usually without chlorophyll. (*f*) Small parenchyma cell with an abundance of chlorophyll. (*g*) Sheath cells of the fibro-vascular bundles. (*h*) Schlerencyma cells of the fibro-vascular bundles. (*i*) Xylem cells of the fibro-vascular bundles.

FIGS. 2–16.—Intranuclear bodies found in the leaves of mosaic sugar cane, showing variations in character.

FIGS. 17–22—Intracellular bodies from the stems of mosaic canes.

FIG. 23.—A degenerating nucleus and a protoplasmic mass which appears be an intracellular body.

FIG. 24—Two bodies from cells that do not show nuclei.

FIG. 25–34.—Enlarged and abnormal nuclei from white areas of mosaic leaves.

FIG. 35, 36.—Cells from a white area of a mosaic leaf showing enlarged nuclei with intracellular bodies in close contact.

FIG. 37.—Two cells from the stem of a mosaic cane. One showed an enlarged and the other a degenerating nucleus.

FIG. 38 --Normal nucleus from healthy cane.

FIG. 39 (*a–j*).—A series of outline drawings of nuclei from mosaic tissues beginning with the outside leaf and working inward. Each letter represents a leaf. The nuclei in the outer leaves are apparently normal while those in the inner leaves are abnormal in form and size.

FIG. 40.—Cross section of normal sheath cell, showing normal nucleus and chloroplasts.

FIG. 41.—Cross section of mosaic sheath cell, showing abnormal nucleus and chloroplasts.

FIG. 42--Longitudinal section of normal sheath cell Nucleus 6 6 mm. Chloroplasts 4.4 mm

FIG. 43.—Longitudinal section of mosaic sheath cell. Nucleus 6.6 mm Chloroplasts 2.2 mm.

FIG. 44—Normal parenchyma cells, next to sheath cells.

FIG. 45.—Mosaic parenchyma cells, next to sheath cells.

FIG 46 *a*.—Parenchyma cell from an outside normal leaf.

FIG. 46 *b*.—Parenchyma cell from an outside mosaic leaf.

FIG. 47 *a*.—Parenchyma cell from inside mosaic leaf. Nucleus 4.4 mm. Chloroplasts 3.3. mm.

FIG. 47 *b*.—Parenchyma cell from inside mosaic leaf. Nucleus 7 mm. Chloroplasts 1.5 mm.

FIG. 48.--Parenchyma cell from mosaic leaf showing abnormal nucleus and reduced chloroplasts.

FIG. 49.—Chloroplasts from sheath cells of leaf. (*a*) Normal tissues. (*b*) Abnormal tissues. Note variations in size and markings.

FIG. 50.—Series of outline drawings of chloroplasts from leaves of

mosaic plant. The letters start with the outside leaf; the small drawing for each letter represents the relative size of the chloroplasts from the mosaic area as compared with the size of the chloroplast from the cells of the normal area. The drawings on the left in each case are from normal, while those on the right in each case are from mosaic cells.

Fig. 51. (*a* and *b*).—Two cells from fibro-vascular bundle of mosaic plant just before the breaking of the cell wall.

Fig. 52.—First stage in the disappearance of the cell walls.

Fig. 53.—Later stage in the disappearance of the cell walls.

Fig. 54.—A protoplasmic mass soon after the disentegration of the cell walls.

Fig. 55.—A section through a normal leaf.

Fig. 56.—A section through white tissue in the early stage of the disease. Parenchyma cells. Note the enlarged nuclei and reduced chloroplasts.

Fig. 57.—A section through the white area of a leaf in the more advanced stage of the disease. Parenchyma cells. Note the enlarged nuclei and reduced chloroplasts.

Fig. 58.—A section through the white area of a leaf in the more advanced stage of the disease. Sheath cells. Note the enlarged nuclei and reduced chloroplasts.

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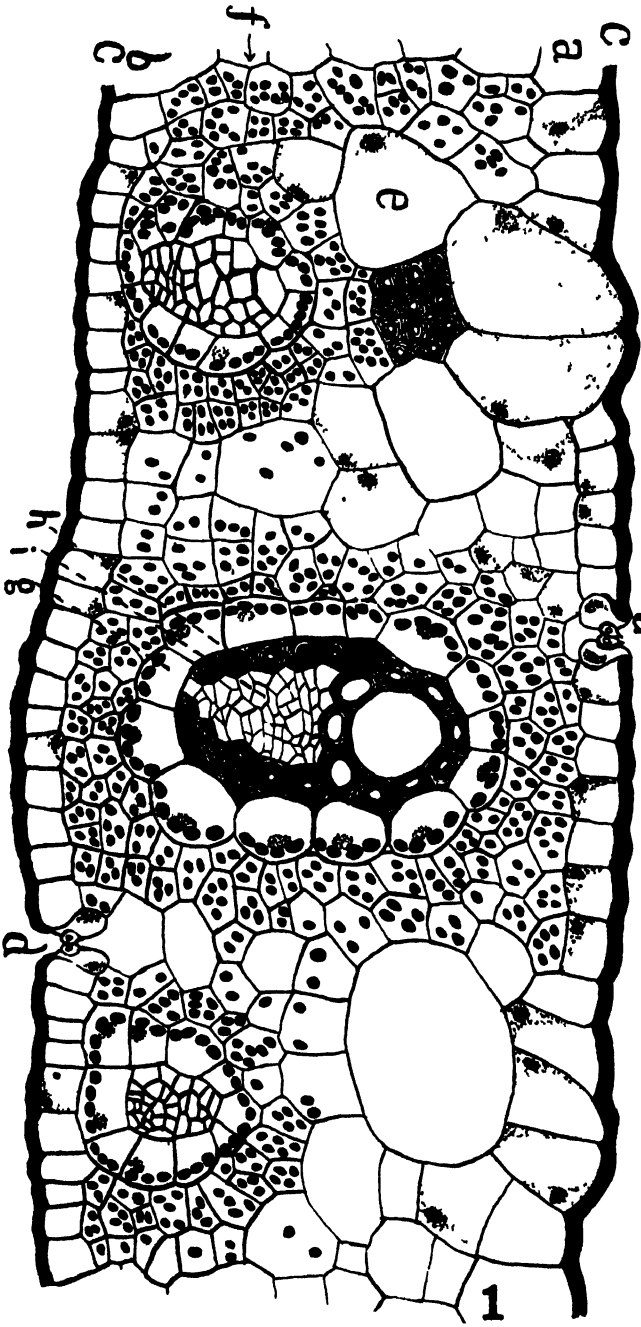
Río Piedras, Porto Rico.



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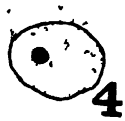

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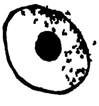

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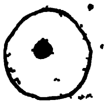

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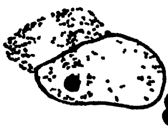

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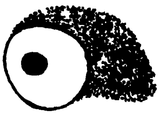

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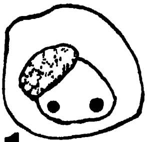
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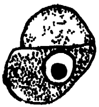
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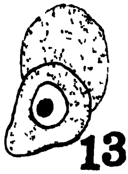
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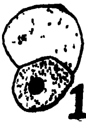
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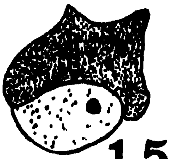
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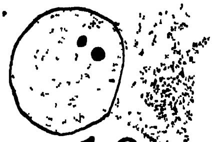
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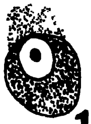
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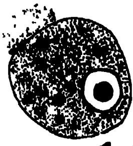
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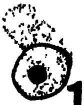
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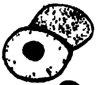
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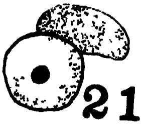
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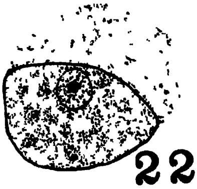
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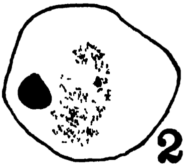
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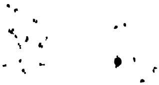
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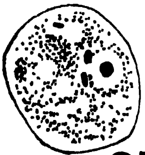
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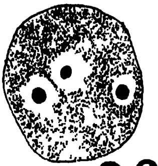
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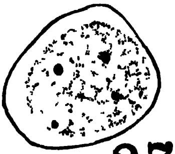
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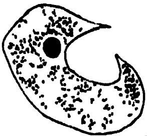
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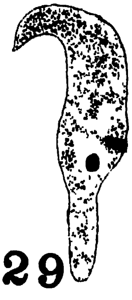
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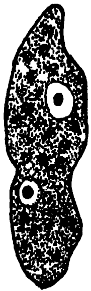
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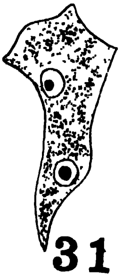
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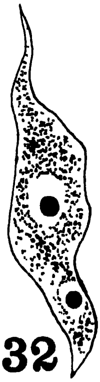
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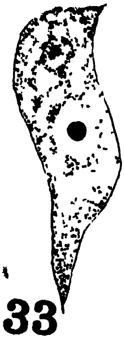
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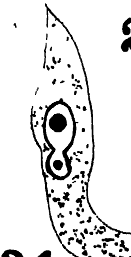
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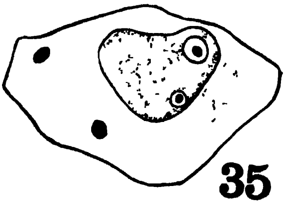
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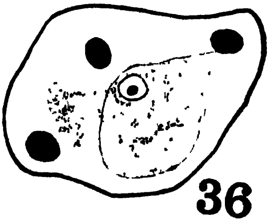
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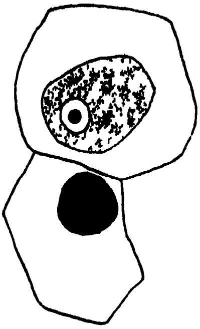

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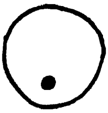

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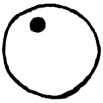

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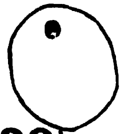

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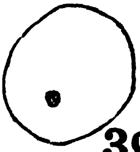

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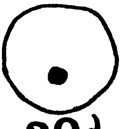

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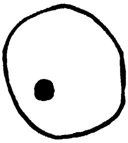

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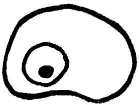

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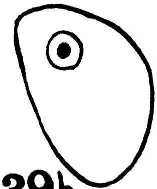

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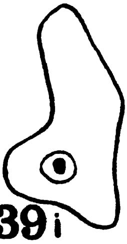

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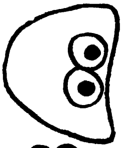

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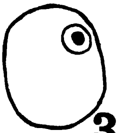

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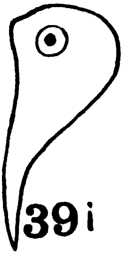

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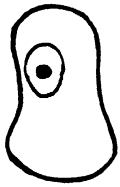

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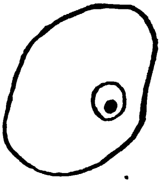

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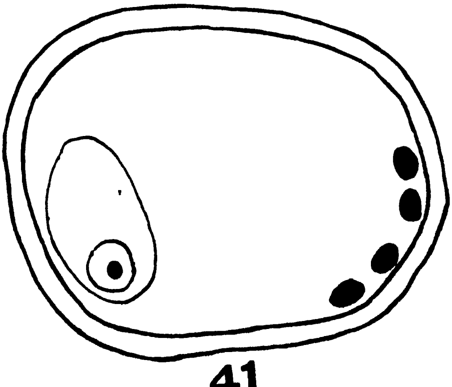

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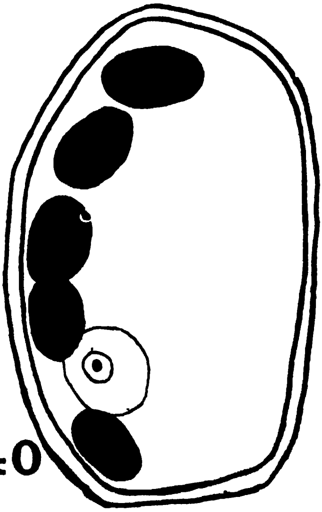

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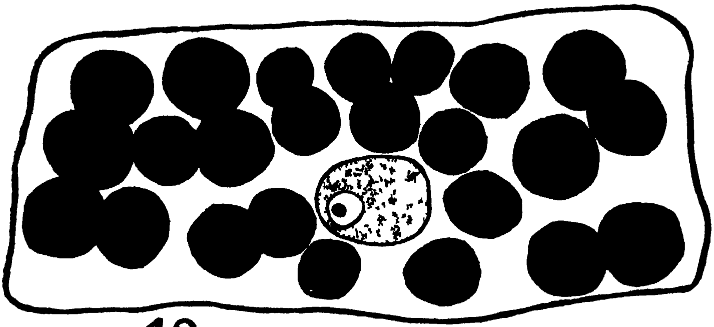

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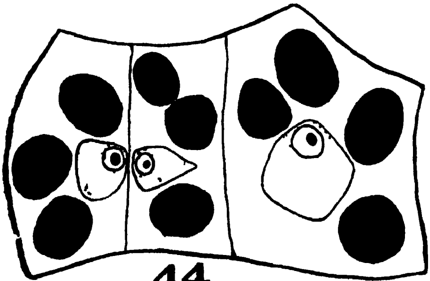

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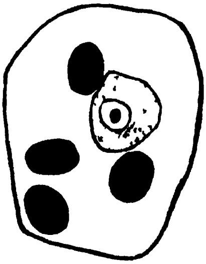

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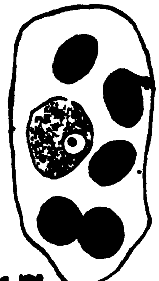

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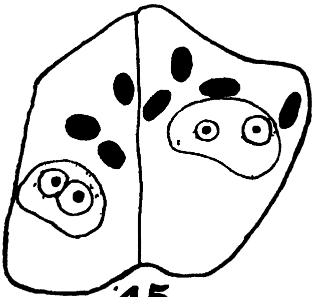

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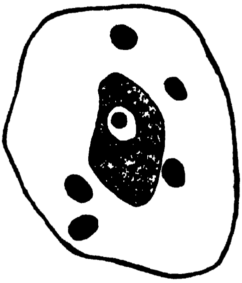

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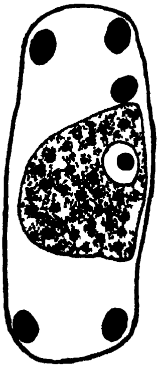

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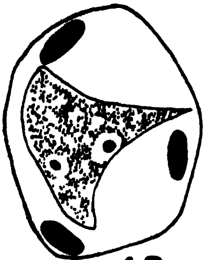

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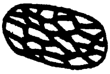

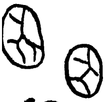

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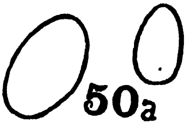

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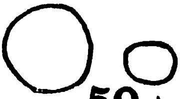

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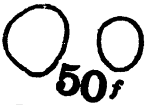

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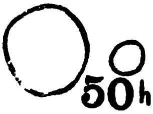

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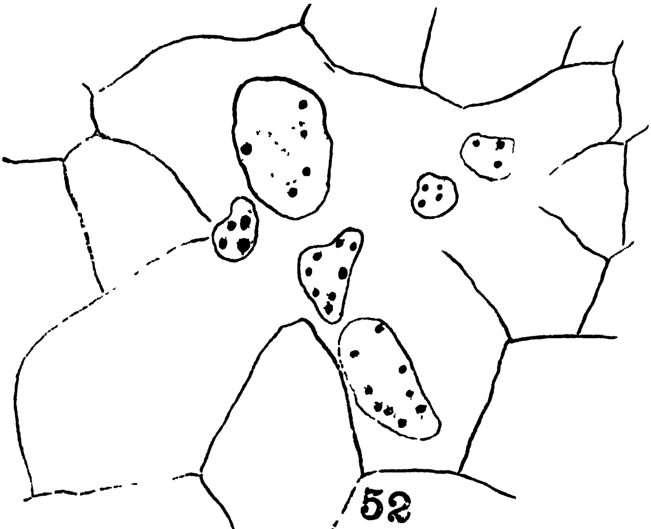

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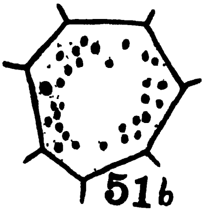

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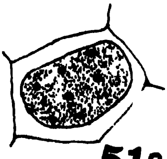

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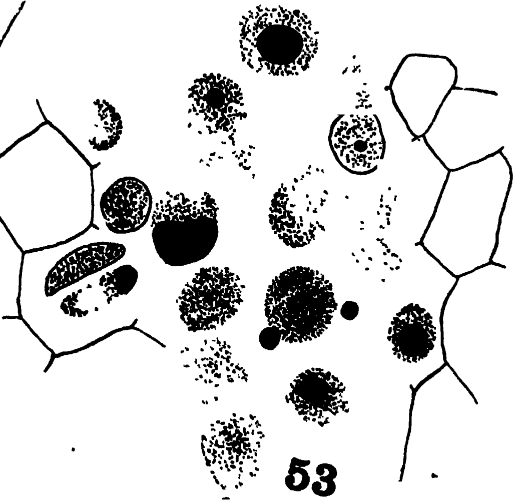

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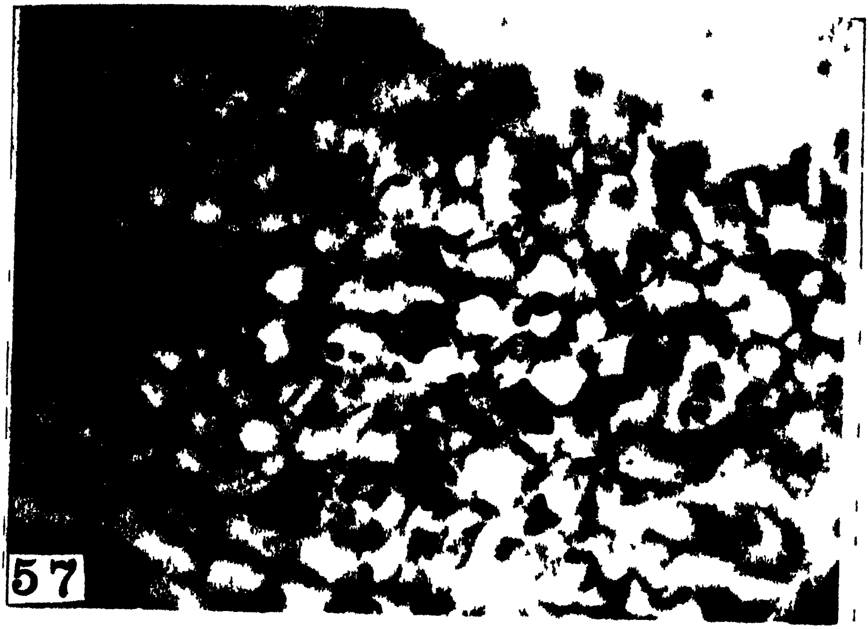

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THE QUEENSLAND RASPBERRY (*Rubus probus*)

A SPECIES ADAPTED TO TROPICAL CONDITIONS

J. P. GRIFFITH, Plant Breeder, Insular Experiment Station

ORIGIN

The Queensland raspberry is said to be of stock originating with James Pink of Brisbane, Australia, as a reported cross between a variety received from Japan under the name *Rubus ellipticus,* and *Rubus rosaefolius,* the latter being the pistillate parent.

A letter dated November 26, 1923 was addressed by the writer to Mr. James Pink for further information concerning the origin of the Queensland raspberry, as well as to ascertain something of the conditions under which the berry was produced and the extent of its culture in Australia. It was also our plan to compare the original stock with that introduced to Porto Rico in 1912, which Dr. Bailey believes to be a second-generation cross and which may show points of difference from the original (first generation hybrid).

On January 21, 1924, Miss Jane M. Pink, sister to Mr. James Pink wrote from Brisbane that her brother had passed away on November 2, 1923. He had been so ill during the last few years that he had been unable to get into his experimental garden. As a result the garden became a wilderness and the raspberry in question had evidently died out.

Later a column in one of the Australian papers told of the work of Mr. Pink. An extract from this follows:

> "Mr. Pink was a noted student of the Mendelian system of plant breeding and on many occasions showed his proficiency in crossing types in Queensland, some of which were found to be of high merit. One of the most useful examples of cross pollination accomplished by the deceased gentleman and an eminent success was the crossing of the wild native raspberry (evidently *Rubus rosaefolius*) with the Himalayan variety (*Rubus ellipticus*) introduced by Mr. William Soutter many years ago when in charge of the Acclimatisation Society at Bowen Park."

THE PORTO RICAN STOCK

In 1912 the U. S. Department of Agriculture sent to the Porto Rico Experiment Station, Mayagüez, plants of the Queensland berry under the Bureau of Plant Industry Number 23748, with the note that it was a hybrid raspberry, combining *Rubus rosaefolius* (the staminate parents), with *Rubus ellipticus* (the pistillate). An il-

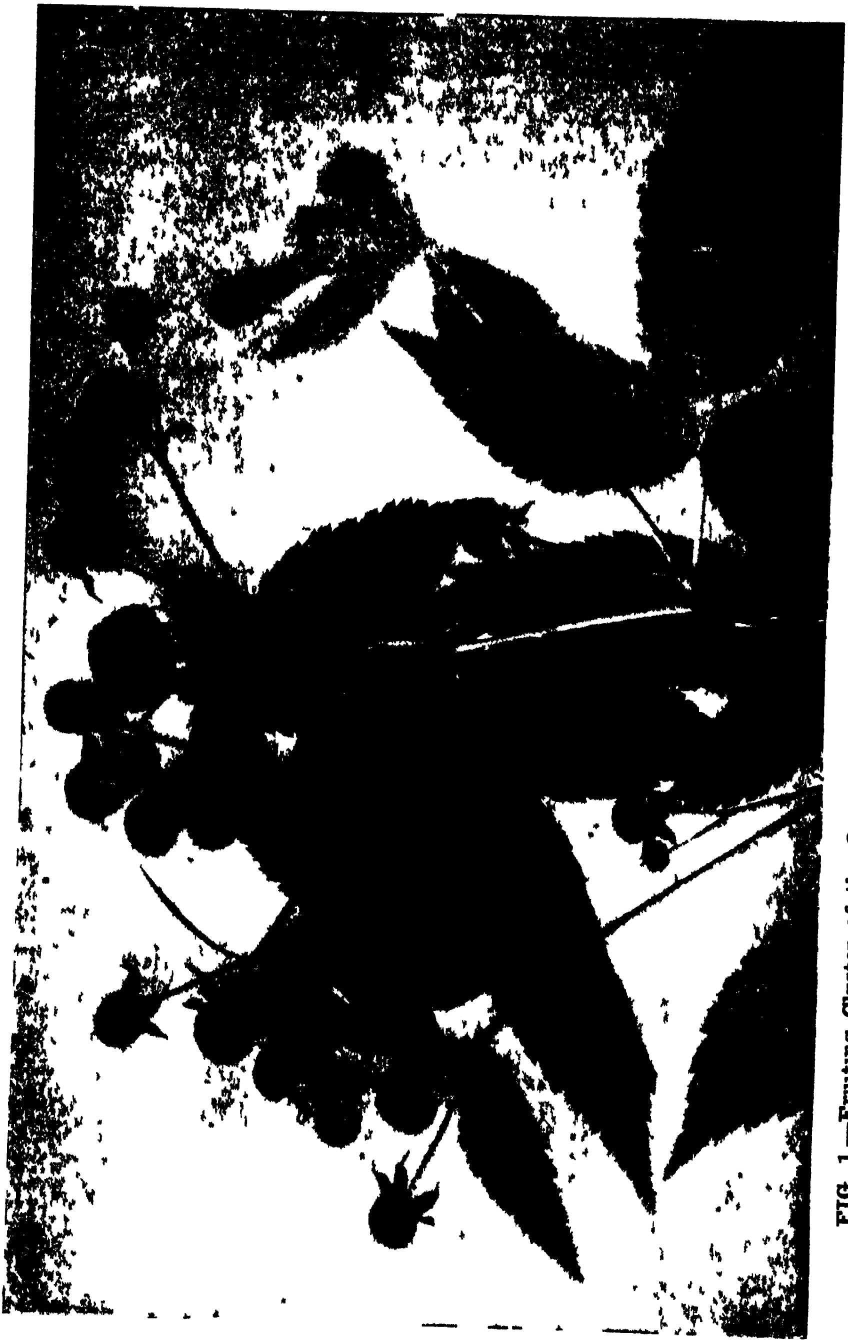

FIG 1 —Fruiting Cluster of the Queensland Raspberry (*Rubus probus*) (Size greatly reduced)

lustration of a fruit cluster appears in the 1912 Annual Report of the P. R. Experiment Station, without notes regarding the berry.

The writer's first experience with the Queensland raspberry was about ten years later when in 1921 he took up the position of horticulturist with the Insular Experiment Station, Río Piedras. At that time there was a planting of about ten plants of the Queensland berry together with two other species, of which our naturalized raspberry, *Rosaefolius*, was one, the other being *Rubus bogotensia*. The exceptional vigor and productiveness of the Queensland berry attracted the writer's attention at the time and roused his curiosity as to the specific name of the plant. Somewhat later specimen plants of the Queensland raspberry and *Rubus rosaefolius* were sent to Dr. L. H. Bailey for his extensive Rubus herbarium at Ithaca, N. Y. It was not until 1923 that the Queensland berry was given a specific name and called "Rubus probus" by Dr. Bailey. In his "Gentes Herbarum-Certain Cultivated Rubi", published in November 1923, pp. 150–151, Dr. Bailey calls attention to the newly named species *Rubus probus*, giving a brief description and using the illustration which appeared in the 1912 Annual Report of the Porto Rico Experiment Station.

Bailey's description is largely technical and includes in addition only some brief notes as to the origin of the berry. Dr. Bailey has not we believe, seen the plant under culture and does not know intimately of its horticultural character. Dr. Bailey also includes *Rubus probus* in his "Manual of Cultivated Plants" (MacMillan 1924), see page 355.

It was not until the 1923–25 crop in Río Piedras that the writer realized the possible importance of the Queensland berry to Porto Rican horticulture, though he has written various reports for the Insular Experiment Station and for the local paper, "Porto Rico Progress" (See Dec. 22, 1923, Jan. 26, 1924, Oct. 18, 1924), which tell of the merits of this berry. Mr. George Darrow, Pomologist of the U. S. Bureau of Plant Industry, Washington, in his Department circular 320 (Aug. 1924), "The Van Fleet Raspberry — a New Hybrid Variety", calls attention to the Queensland raspberry, mentioning its culture in Australia and Porto Rico. The latter part refers to my article, "Developing a new Raspberry for Porto Rico" which appears in the *Porto Rico Progress*, Vol. 21, No. 51 p. 8. Plants and seed of the Queensland Raspberry were sent to Mr. Darrow, the former reaching Washington in good condition February 16, 1924.

The best planting so far seen was that made on the grounds of

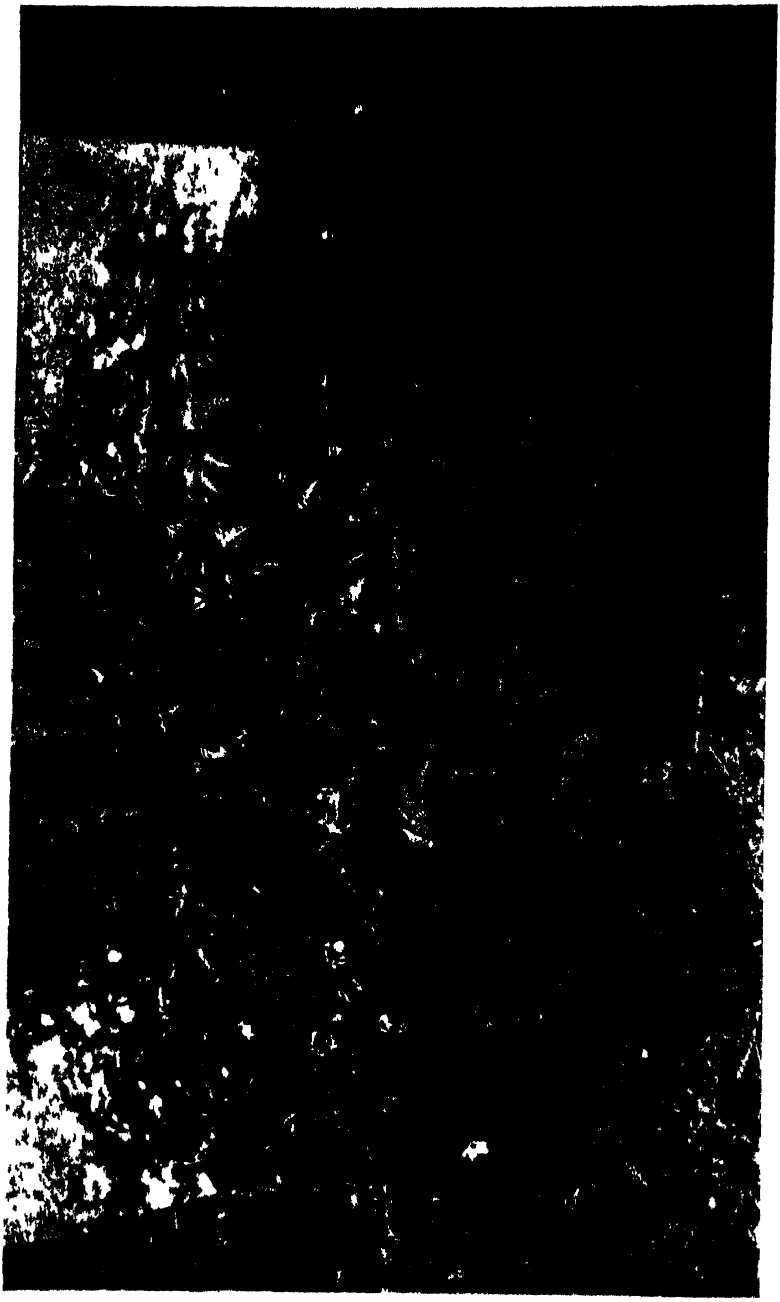

FIG 2.—The Wild Naturalized Raspberry of Porto Rico (*Rubus rosaefolius*), Female Parent of Queensland Raspberry. (Photo original)

the Insular Expt. Station in November, 1923. The 32 plants in this group appeared to reach their maximum development, being loaded with fruit from December 15, 1924, up to about March 1, 1925, when they passed their prime, and from then until March 15 produced only a few fruits. This planting has been used in our hybridization tests.

Other plantings have been made at Mayagüez (also in the lowlands) and at Villalba (elevation about 1,700 feet). At both places the Queensland raspberry has developed and fruited well. Mr. T. B. McClelland, Horticulturist of the P. R. Experiment Station, says that "the Queensland raspberry suffers considerably from the dry season there in Mayagüez. Plantings made during the dry winter period are sometimes killed entirely, but when the water supply is adequate, the plants develop well". Mr. McClelland thinks the berry worthy of wide distribution in Porto Rico. We have had favorable reports of the behavior of mature plantings of Queensland raspberries from the north, west and south sides of Porto Rico, but, to gain fuller information, plantings have been made at the government test farms located in the towns of Trujillo Alto, Vega Baja, Arecibo, San Sebastián, Sabana Grande, Villalba and Cayey. These plantings are still young.

Plants of the Porto Rican stock have been sent to Mr. R. S. Nason of Orlando, Florida, who is interested in the improvement of Rubi and tropical fruits in general. Mr. Nason reports that *Rubus probus* is growing well in Florida, but it is too early to give a final report on it there. It will be interesting to know something of the hardiness of this plant.

CHARACTERIZATION

The Queensland raspberry is a vigorous-growing erect or slightly drooping plant, reaching a height of 7 or 8 feet. The stems are large, coarse and glabrous, with a few short, straight spines. It apparently has none of the characters of its male parent, *Rubus ellipticus*, unless a vigorous vegetative quality has been inherited by *Rubus probus*. On our grounds we have a planting of *Rubus ellipticus* adjoining that of the Queensland berry, with a planting of *R. rosaefolius* also near, so that the three may be readily compared. *Rubus ellipticus* makes a rank vegetative growth, up to 10 or 12 feet, has coarse stems with heavy red pubescence and long sharp, curved spines. *Rubus rosaefolius* is a weak decumbent plant, growing up to only about 3 feet in height.

It is a more spiny plant than *R. probus*.

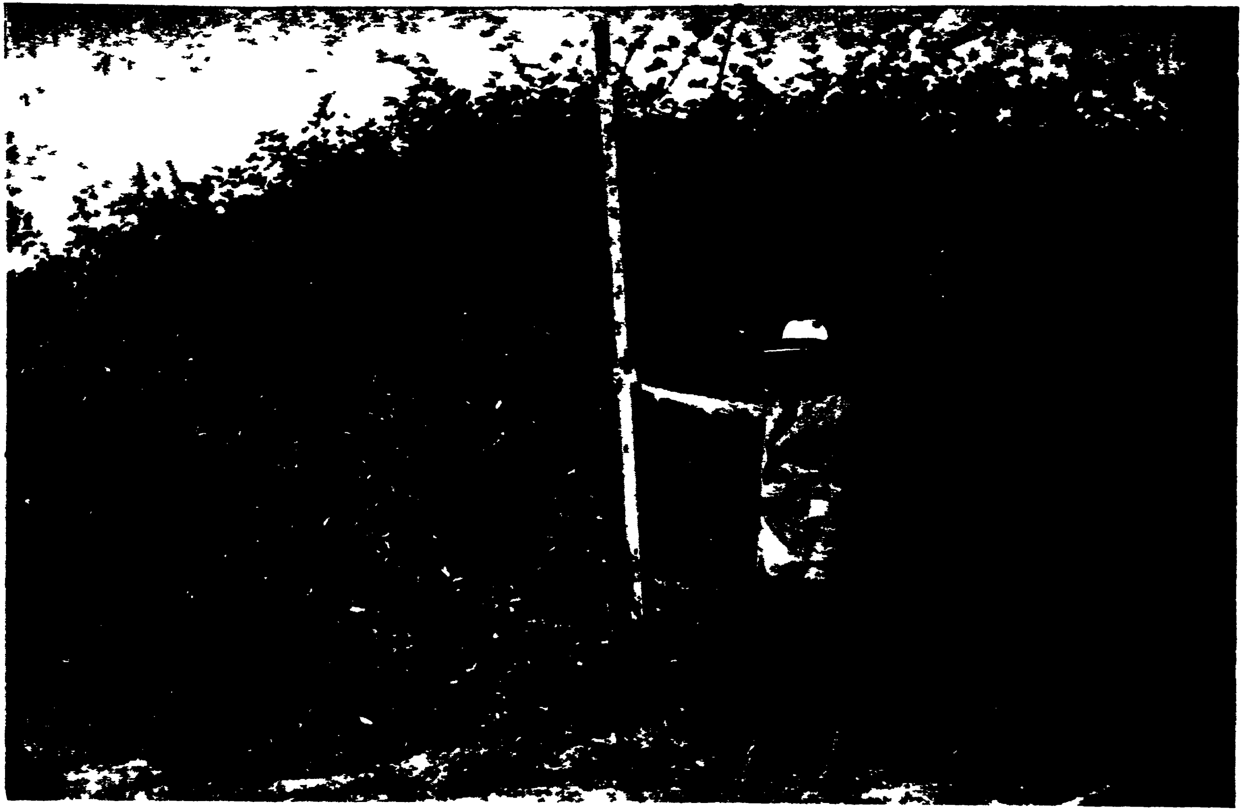

FIG 3 —The Himalaya Raspberry (*Rubus ellipticus*), Male Parent of the Queensland Raspberry. Stake held by writer is nine feet high

Technical description:—(after Bailey) "*Rubus probus* is related to *Rubus rosaefolius*, differs in being glabrous on petioles, leaf blades and pedicels, less thorny: leaflets 3 to 9, but usually 7 and relatively much broader, ovate lanceolate to nearly ovate on short fruiting branches, margins more deeply and sharply serrate, veins very prominent; flowers more clustered; calyx lobes acute to short cuspidate little if at all exceeding the petals; fruit red seedy depressed endwise so that it has a flattened appearance, detaching from the receptacle in the form of a ring. · Plant upright about 8 feet high; canes not perennial, somewhat bending, but not climbing; leaves 8 to 10 inches long on vigorous growths and leaflets to 4 inches long." "Certain Cultivated Rubi" page 150).

Rubus probus suckers readily from the root, throwing up strong, vigorous, rapidly growing shoots from the fleshy roots of the plant. In the strong character of its suckers, *Rubus probus* more closely resembles *R. ellipticus* than it does *R. rosaefolius*.

The fruit of *Rubus probus* is produced very abundantly, many clusters setting 8 to 10 berries, as shown by an accompanying illustration. The writer counted 33 berries on a clump of three clusters grouped together. The berries when fully matured are large and flattened and of fairly good flavor though not comparing so favorably with the best northern raspberries, lacking the distinctive character of the latter. The individual berries of *R. probus* are larger than those of either parent fruit of the Queensland berry, is rather perishable and crumbles too easily for a good shipping berry. A large quantity of fruit has been sold from the Station grounds the past season for 15 cents a pint and is evidently appreciated by the native Porto Ricans. Continental Americans who are familiar with northern raspberries do not react so favorably towards the Queensland berry, but some who have tried it in the form of jelly or jam speak well of it. The Station Entomologist, Dr. H. L. Dozier, who was not familiar with either the wild berry (*R. rosaefolius*) or with the Queensland berry before coming to Porto Rico recently, pronounced the latter to be of better flavor. The writer also prefers the fruit of the fully mature Queensland berry. Many of those who have known the northern raspberry may acquire a taste for the Queensland berry by continued use.

Considerable quantities of the wild berry (*Rubus rosaefolius*) are constantly being sold at points in the hills of Porto Rico, near Aibonito, where the berries reach perfection, and on the Cayey-Guayama road. An accompanying photo illustrates this berry. The children

FIG. 4.—The Queensland Raspberry (*Rubus probus*), Showing Vigorous Young Sucker Plants.
Photo, Insular Station, 1925.

gather the fruit under the shade trees in the coffee plantations and sell them for about 10 cents a quart to passing tourists. The fresh fruit is also sometimes carried down from the hills in small straw baskets and sold in San Juan. The wild berry is put up in the form of jelly and jam by an Aibonito hotel and by private individuals living near the town, who prepare the product for sale in San Juan.

Some comparisons between the Queensland raspberry and our naturalized wild berry are interesting. From a fruiting standpoint, *Rubus probus* has several advantages over *R. rosaefolius*. The former produces large clusters of fruit as we have noted above, sometimes running ten to the cluster. *R. rosaefolius* produces only a single fruit on a terminal. The fruits of *Rubus probus* are large and of better flavor than those of *R rosaefolius*. However, if the fruits of *R. probus* are picked before fully mature they are too acid to be very palatable. Both *R. probus* and *R. rosaefolius* have very perishable fruit, to the thimblelike shape of the latter is more desirable. The fruits of *Rubus probus* reach their full development in both the lowlands and highlands of Porto Rico, while *R. rosaefolius* reaches its maximum only in the higher elevations of the Island.

As regards plant development, the Queensland berry has also certain advantages over the native berry. The Queensland berry will develop normally in bright sunlight under open field conditions, while the *Rubus rosaefolius* requires a part shade for its proper development, and so is not suited for field culture. The Queensland berry makes a vigorous erect plant growth and the suckers "take hold" readily when field planted. The wild berry makes a weak, low, spreading plant growth and is very difficult to establish by suckers. The tall growth of the Queensland berry permits easy picking of the fruit, while the wild berry is so low and produces so sparingly that the harvest is difficult.

PROPAGATION

The Queensland raspberry propagates very readily in three forms. The quickest method of establishing a plantation is by the use of suckers, which are always abundant. Plants may be grown from root cuttings 4 to 6 inches in length by bedding them in sandy soil. Practically all will sprout strong plants. We find that *Rubus probus* comes more readily from seed than most other berries with which we have been working. Our best results have been obtained on a steam-sterilized sandly soil. The seedling method is, of course, a slow way of producing plants. In order to determine whether our stock of the species, *R. probus*, is a pure one, some 200 seedlings were raised at the Insular Station in 1924. They showed no noticeable variation from the parent type.

In connection with the germination of Rubus seed we have received some interesting information from Dr. Chas. A. Shull, plant physiologist at the University of Chicago, and from Mrs. Opal Davis, formerly in Chicago but now at the Boyce-Thompson Institute for Plant Research, Yonkers N. Y. This relates to the treatment of Rubus seed with sulfuric acid to hasten germination and is a con-

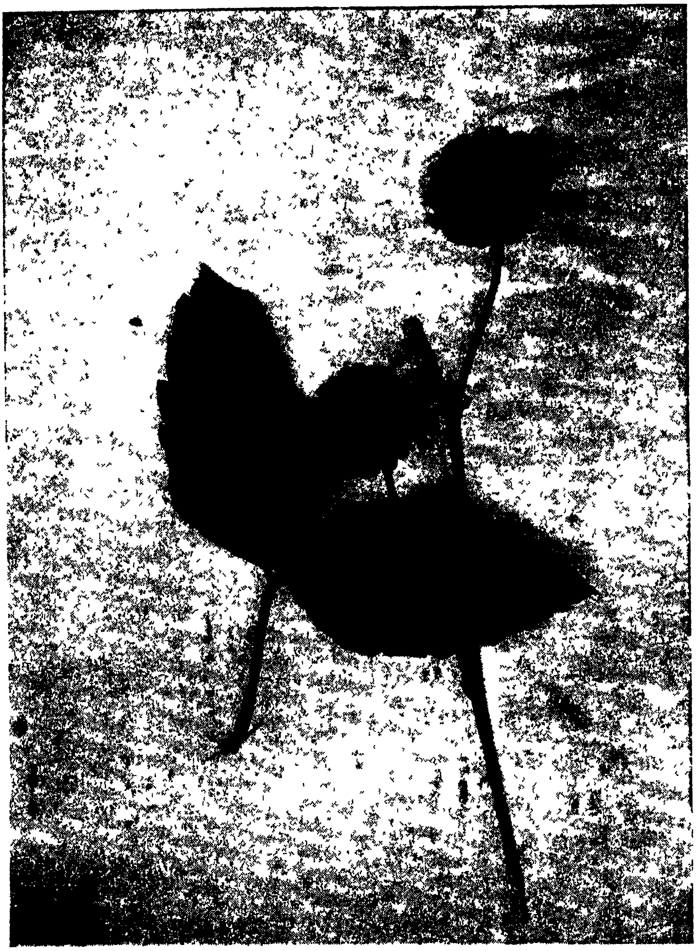

FIG. 5.—A Hybrid Raspberry *Rubus probus* (Female) × *Rubus strigosus* (Male) Produced in January, 1925 (Cuthbert Raspberry the pollen bearer)

tinuation of the study started by R. C. Rose in 1919. In Rubus the dormancy is due to the high breaking strength of the pericarp, which is eliminated by treatment with acid under proper conditions. In the case of *Rubus rosaefolius* a 95-per cent germination was obtained by treating the seed with sulfuric acid sp. gr. 1.84 for 45 mins. and somewhat over 50 per cent germination with the same treatment for *Rubus probus,* tho Dr. Shull believes a one-hour treatment would probably give better results in the case of the latter species. Mrs. Davis is now studying the possible effect of a rest period on the germination of *Rubus probus* seed treated with acid. We have sent her some one-year-old seed for this work.

The best distances for field planting *Rubus probus* are 8 feet between rows and 5 to 6 feet between plants in the row. This allows for maximum development. On Porto Rican soils it will be found advisable to place well-rotted manure under the plants at time of setting. Later a mulch of dried grass around the plants will be found beneficial. In keeping the field of Queensland raspberries free of weeds, it has been noticed that the use of the hoe in severing the roots of the berries causes many suckers to spring up. Unless the young plants are removed they sap the life of the main plant thereby preventing a proper set of fruit.

TRAINING

Very little training is necessary in the case of *Rubus probus* as the plants grow quite erect, drooping only slightly. By placing heavy end posts extending some 6 feet above the ground with 3-foot cross bars of 1″ by 4″ material at the 2 and 5 foot levels and stretching wires along the sides of the berry rows, the canes will be held from spreading out too much.

GENERAL OBSERVATIONS

While we consider the Queensland raspberry as worthy of more extended planting in Porto Rico, because of its strong plant growth and its great productiveness, the quality and shape of the fruit are defects which we are seeking to remedy by hybridizing *Rubus probus* with northern raspberries of high quality. As a start in this direction, we have crossed the Cuthbert (*Rubus strigosus*), a high quality red raspberry (note photo of Cuthbert plant we have used as a pollenizer) with *R. probus,* which makes an excellent pistillate parent under our conditions. From the resultant fruit of this cross (note illustration) we have obtained several hundred seeds for planting. We have also crossed the Manatee dewberry (*Rubus trivialis*) with

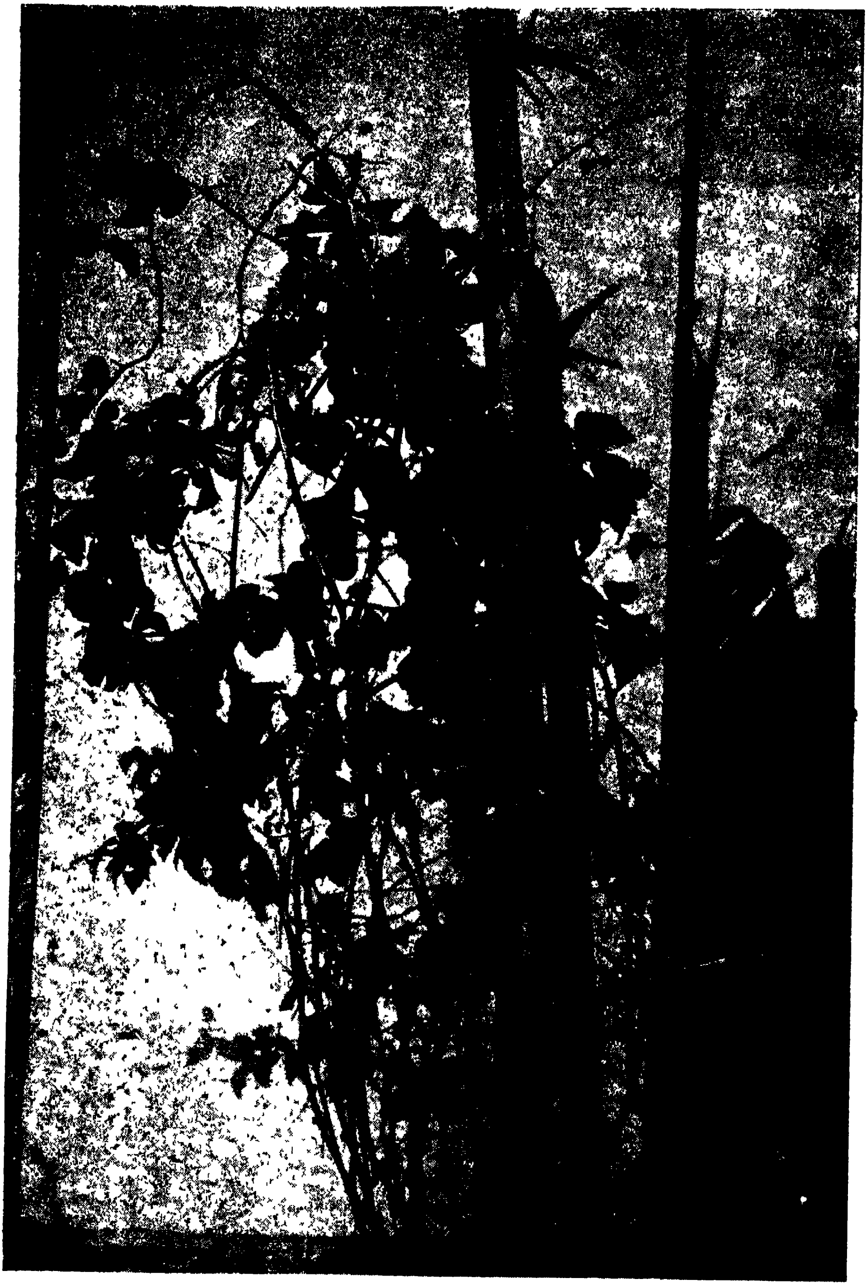

FIG. 6.—The Cuthbert Raspberry *(Rubus stringosus)* in Porto Rico. Pollen parent used to hybridize the Queensland Raspberry *(Rubus probus)*

Rubus probus and from a few crosses find that the pollen of the dewberry is decidedly congenial to *probus* stock—much more so than Cuthbert, which gave rather poorly formed fruit in some cases, tho plenty of pollen of the Cuthbert has been available over a period of two months or more. Our best results in the *probus-strigosus* cross were obtained where the Queensland berry flowers were not exposed to the hot midday and afternoon sun.

Heretofore the Rubus work of the Insular Station has been handicapped by not having the proper conditions in the hills of the Island, as mentioned in the 1923–24 Annual Report of the Insular Experiment Station. We have lately found a desirable spot near Aibonito at the 2,000-foot level, where 18 species and varieties of raspberries, blackberries and dewberries have been planted.

Our experience has so far shown that most of the Rubi from the United States, especially those from the northern sections, will not develop well under tropical conditions, the two diseases, Leaf-spot (*Septoria rubi*) and Anthracnose (*Gloesporium venetum*), being too much for them, causing defoliation and in some cases death of the plants. Quite a contrast is offered by *Rubus probus* growing near by which is untouched by these diseases. The plants from northern sections lack vigor in Porto Rico, which increases their susceptibility to diseases here. The blackberries and dewberries from the southern United States make the most vigorous plant growth of the Rubi brought from the States and are quite resistant to disease. We are bringing some of the varieties through the flowering stage so that pollen of the high-quality berries may be used in the hybridization of some of the tropical forms which produce fruit more or less lacking in quality Some of these with which we are working are *R. ellipticus, R. moluccanus, R. probus, R. niveus, R. glomeratus, R. thunbergii and R. macrei* (discussed in my *Florida Grower* magazine article, Dec. 6, 1924). Varieties which have flowered and in some cases set fruit for us are Cuthbert raspberry, Manatee dewberry, Advance blackberry, *Rubus hybridus* and *Rubus ellipticus*, the last named having been brought from Jamaica, where the plant has become naturalized in the hills.

The distribution of promising agricultural crops in Porto Rico will from now on be facilitated by the establishment of the government test farms elsewhere referred to in this article. These farms are located in the various districts and the planters can see for themselves the possibilities with certain crops and obtain stock for starting their own plantings.

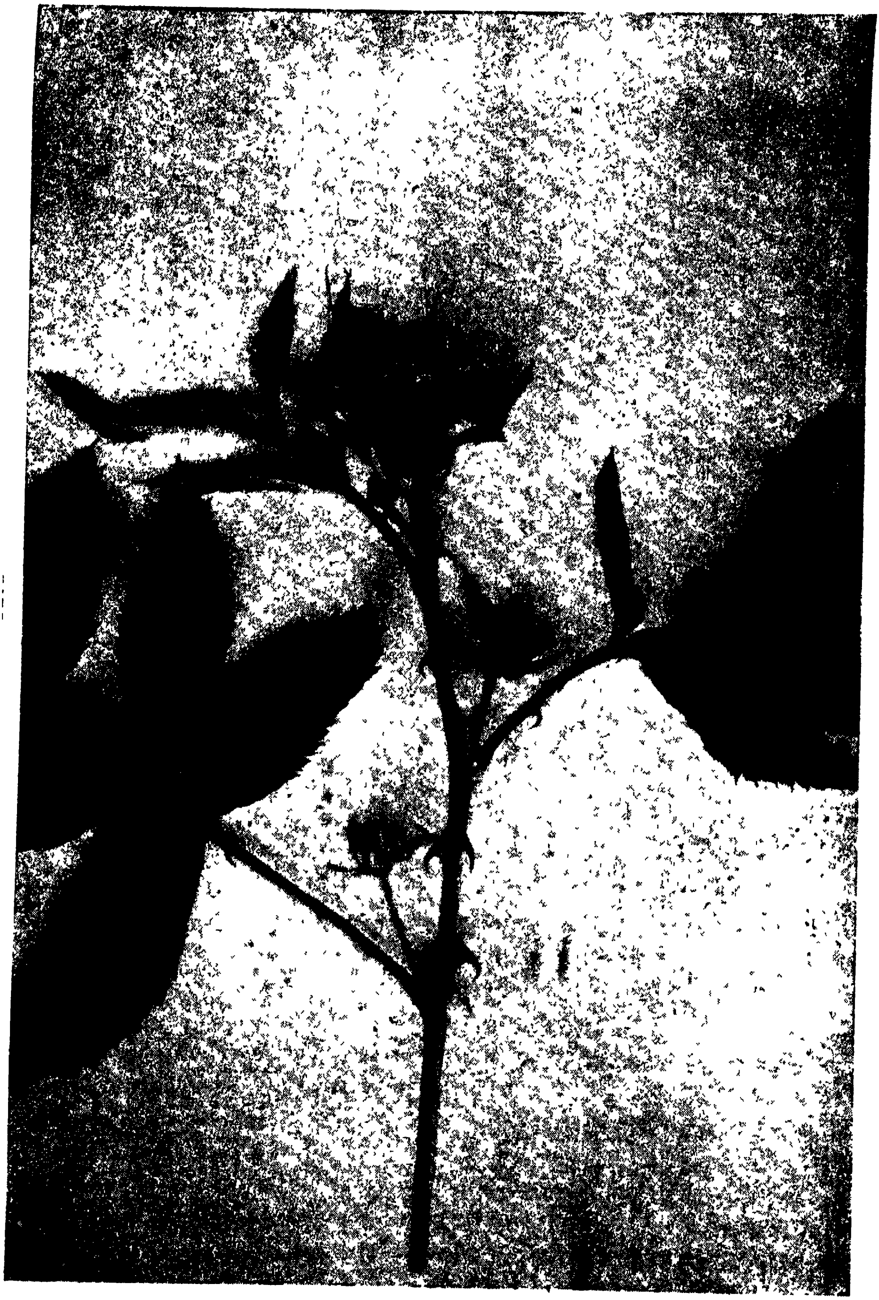

FIG. 7.—Inflorescence of the Ceylon Raspberry (*Rubus* sp. ?) (Enlarged 1/3) Photo by Dr. H. L. Dozier, April, 1925

A CEYLON RASPBERRY (*Rubus* sp. ??)

ONE OF THE MOST PROMISING OF THE TROPICAL BERRIES UNDER TEST BY THE INSULAR EXPERIMENT STATION OF PORTO RICO

The Ceylon berry was supplied together with five other species by the Royal Botanic Gardens of Peradeniya, Ceylon, coming originally from the Hakagala hill gardens of Ceylon. The seed was sent from Ceylon on November 27, 1923, and arrived in Porto Rico in March, 1924. The first fruits from the March, 1924, planting began to mature in Río Piedras in April, 1925.

BOTANICAL DESCRIPTION OF THE CEYLON RASPBERRY

Plant: 3–4 m. high, terete, glabrous, heavily glaucus-pruinose, armed with sharp curved spines, about 1 cm. long; *leaves*, pinnate with 5 to 7 leaflets usually 7, petioles 9–15 cm. long with sharp recurved spines, mostly on underside; petiolules and midveins slightly prickly; terminal leaflets, petioluled rhomboid 5–8 cm. long, glabrous and dark green above, white-tomentose beneath (being whiter beneath than leaves of *R. glaucus*) cordate at base, doubly serrate, accuminate, palmately veined, veins prominent; side leaflets nearly sessile, lanceolate-ovate; *inflorencence*, clustered at the terminal, appears also in upper leaf axils, branches tomentose; sepals lanceolate, pubescent, gradually acuminate, 6–8 mm. long, in fruit strongly reflexed; petals broadly ovate, color pink or old rose; 5 mm. long by 5 mm. wide, pistils a dark red color.

Fruit, dark purple covered with fine hairs giving it a pruinose effect 10 to 15 mm. long and 15–20 mm. thick, shape conical. Produce 6 to 8 fruits in terminal clusters and 1–5 (usually 1–2) fruits in each of the axils of leaves. Average 20–25 fruits per fruiting branch.

In planting the Ceylon species of Rubi, the seed of some unfortunately became mixed and the preceding species which we have found necessary to describe is one of these. We are hoping to obtain the true species name either from the Royal Botanic Gardens, Peradeniya, Ceylon, or from the New York Botanical Gardens to which places we have sent herbarium material. The Ceylon raspberry (*Rubus* sp.) makes a strong vigorous plant growth and fruits quite abundantly under Porto Rican conditions. In practically every respect the Ceylon raspberry described on the following sheet resembles the black raspberry, excepting the color of the fruit and the slight difference in the shape of the berry. The Ceylon berry

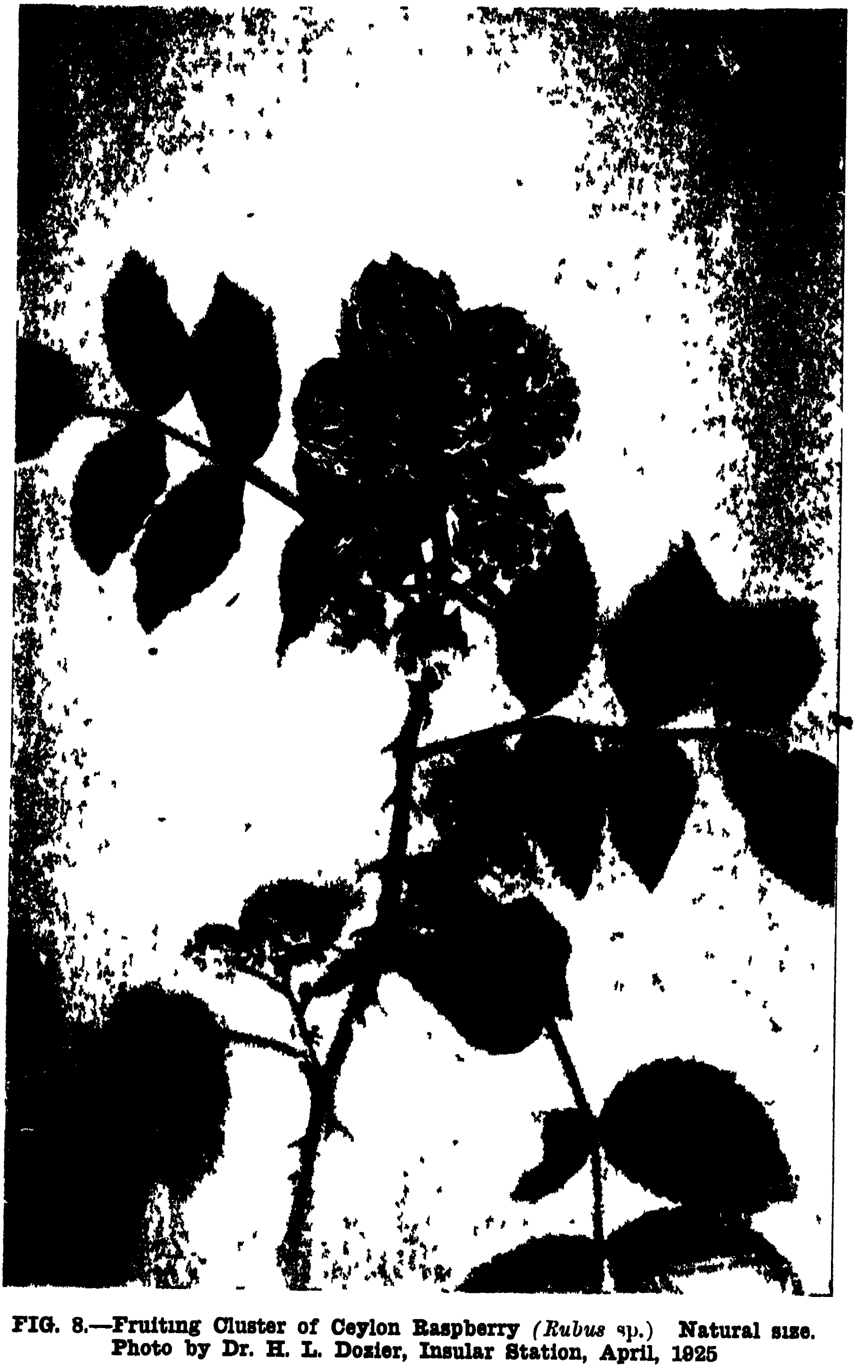

FIG. 8.—Fruiting Cluster of Ceylon Raspberry (*Rubus* sp.) Natural size. Photo by Dr. H. L. Dozier, Insular Station, April, 1925

roots at the tips of the canes so that large numbers of small plants can be readily secured.

The Ceylon raspberry, aside from its possible merit for cultivation in tropical countries, has a greater possibility, perhaps, as a hybridizer to use in connection with the American black raspberry In the North the black raspberry is very susceptible to a serious disease, the anthracnose (*Gloesporium venetum*) which shortens the life of commercial plantations and so is more or less a limiting factor in the profitable cultivation of the crop. The United States Department of Agriculture is interested in crossing the black raspberry which Rubi which make a strong plant growth and which are resistant to disease (particularly anthracnose) and it seems that the Ceylon raspberry may be just the pollen parent to use in this hybridization work as so far our tests have shown the Ceylon berry to be resistant to both anthracnose and leaf-spot (*septoria rubi*). Seed and young plants of the Ceylon berry will soon be available for use by the U. S. Department of Agriculture and other experimenters in the United States or elsewhere who may care to work with the species.

ON THE AMOUNT OF FOOD EATEN BY INSECTS[1]

George N. Wolcott, Entomologist, Insular Experiment Station.

In the course of another investigation, it became desirable to know how much food insects ate expressed in terms of the weight of the insect itself. A search of literature gave surprisingly little exact data on this point.

The caterpillar of *Telea polyphemus* Cramer, as noted by Trouvelot (I), "when 56 days old—is fully grown and has consumed not less than 120 oak leaves, weighing three-fourths of a pound; besides this it drank not less than ½ oz. of water. So the food taken by a single silkworm in 56 days equal in weight 86,000 times the primitive weight of the worm (1/20th grain). Of this, about ¼th lb. becomes excrementitious matter, 207 grains are assimilated and over 5 oz. have evaporated."

The amount of corn leaves eaten by the armyworm, *Cirphis unipuncta* Haworth, has been measured in square inches (2), and the amount of clover leaves eaten by the weevil, *Hypera punctata* Fabricius (3). None of this data however, was in terms of the weight of the insect, and for the first experiment, the tobacco hornworm, *Phlegethontius sexta jamaicensis* Butler, was chosen because of its large size, rapidity of development, availability in Porto Rico, and incidentally because of its economic importance.

Hornworm eggs weigh .00105 gram each, and the just hatched larva .0004 gram. The caterpillars were kept in small glass dishes with tightfitting covers, the size of the dish being increased as the caterpillar grew and needed more room. The food of the caterpillars in the first instar was not weighed, as the amount eaten was so minute, but the larvae were weighed daily, and their food and excrement in succeeding larval instars. The figures of daily consumption of food and gain in weight of the caterpillars were not comparable, as the larvae might recommence eating after molting at any time of day or night. But in general, they showed enormous consumption of food relative to the weight of the larva in the first, or first two, days of the instar, but actually larger consumption of food the last day previous to the pre-molting period because of the increased size of the larva. The apparent gain in weight was also greater in the first day or days of each instar because of partly digested food with which the alimentary canal was filled, and there was an apparent loss in weight in the pre-molting period as the digestive tract was emptied. But each instar represents a very definite period of growth, of which the net gain can be readily determined.

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[1] Thesis presented in partial fulfilment for the degree of Ph D at Cornell University, Ithaca, N Y

The Growth of Hornworm Caterpillars

Instar.	Days	Food consumed		Gain in weight				Excrement (Grams)	% of food
		Weight (Grams)	% of Total	Grams	% of total	% Increase	% of food		
Larva "*A*"									
1st	8	.0208 gr	1 %	.0071	.2 %	1750%	84 2*		
2nd... ...	4	.0732 gr	4 %	0285	9 %	406%	88 9		
3rd	5	.4994	2 7	.1118	3 4	508	28 9		
4th	5	1 62	8 7	.5948	18 9	411	86 7	.7446 gr.	45 9
5th	7	16 0367	86 6	3 4976	81 0	588	21.8	10.0082	62.4
Total..	24	18 2501		4 2782		10738	28 4	10 7478 gr. plus	59.
Larva "*B*"									
1st	4	0187 gr	08%	0064 gr.	.1 %	1600	84 2*		
2nd.. .	6	.0788 gr	6 %	0277	5	432	34 9		
3rd	5	4067	1 7	1359	2 7	490	33 4	.1176 gr	28 %
4th ...	5	2 7756	12	8764	17.6	645	31 5	1 5908	57 3
5th	7	19 6591	85 6	3 984	78 9	418	20 0	12.5224	63 7
Total. .	27	22 9889 gr		4 9818		12455	21 7	14.2808 gr plus	61 8
Larva "*C*"									
1st . ..	4	017 gr	0 7	.0058	1	1450	84 2*		
2nd	4	0478	6	.0182	.8	831	32 6	0282	15 7
3rd . . .	4	3334	1 3	.1146	1 9	288	34 2	091	27 2
4th . .	5	2 7845	10 9	1 0188	16 7	889	36 5	1 3612	48 8
5th . .	9	22 1686	87 1	4 9203	80.6	483	22 2	12.9584	58 4
Total.	26	25.4461 gr.		6 1077 gr		15269	24	14 4338 gr	56 7

* Computed average of 2nd, 3d and 4th of all three larvae
Days of 5th instar are those to attain maximum weight, not to pupation

Of the food consumed, between a fourth and a fifth becomes caterpillar, and nearly two-thirds excrement. Both fresh tobacco leaves and fresh excrement contain about 86 per cent water—oven-dry leaves are 14.2 per cent of their fresh weight and oven-dry excrement 14.01 per cent—and presumably the caterpillars contained as high a percentage of moisture; thus the figures on fresh leaves, living caterpillars and moist excrement are about the same in relation to each other as those of oven-dry material. The data on excrement appears to show a decreasing digestibility of the food as the caterpillars increase in size, and the last pellets excreted before pupation are lighter in color and possibly not as thoroly digested as the others. But, aside from this, it actually indicates a partial drying-out of the excrement in the earlier instars because of the proportionately larger container used for the caterpillars when they were small. An average of the figures for the excrement for the 4th and 5th instars—54 per cent of the weight of the food consumed—is probably approximately correct for the entire larval period. The smaller net gain of the caterpillar from the food consumed in the last instar is due to the physiologic changes occurring in preparation to pupation and not to a difference in digestibility of the food. These physiologic changes and the ordinary muscular activities of the caterpillar entail the production of urates and other waste products. In addition to the undigested food, the pellets of excrement contain these waste products, which correspond to the urine in higher animals. As these two constituents of the excrement can not be mechanically separated, the presence of the urates adds another factor of error in the data on the excrement. It is however, a relatively constant element for most non-active caterpillars, and will increase considerably in amount in the last instar. The digestibility of, or rather, the net return from, tobacco leaves by hornworm caterpillars is around 40 per cent, most of which becomes caterpillar in the earlier instars, but nearly half of which is used up in internal changes in the final larval instar.

The data on maximum net gain are not so accurate as might be wished, for the weighing should be made as soon as the last pellet of excrement is eliminated, and not at the convenience of the experimenter, as the daily loss in weight after the maximum is reached, at least in the fifth instar, amounts to about a third of the live weight, and as is later shown, the pupa weighs scarcely half the maximum of the larva. The remaining difference between food and caterpillar plus excrement is accounted for as losses of respiration of CO^2 and H^2O from the caterpillar, and from the leaf after weighing before it was consumed. Fresh tobacco leaves lost twenty to twenty-five per cent of their weight the first day kept in tightly-covered glass containers, and the caterpillars never obtained all of the moisture they are credited with. There is also a loss of from one to three per cent at each molt—the weight of the cast skin—and possibly an even greater, but incalculable, loss in the molting fluid.

For comparison with vertebrates which develop rapidly, the pounds of dry matter per day for each one hundred pounds of live weight of chickens and ducks, as given by Mr. Wm. P. Wheeler (4) is:

	Chickens	Ducks	Hornworm Caterpillars
First two weeks.	10.1	17.2	20. (first four instars)
Two to four weeks	9.6	17.0	46. (fifth instar)

The large consumption of food in the last instar of the caterpillar, is for the internal activities and changes, and maintenance, until the adult can obtain food. It is surprising that a sluggish, cold-blooded insect should consume so much more than active birds which have a high body temperature to maintain, even tho the birds are able to digest, on the average, twice as much of their food.

The caterpillar of *Phlegethontius sexta* attains in 26 days, 12,486 times its original weight (1/2500 gram) and has eaten an amount of food 55,600 times its primitive weight; that is, in half the time required by *Telea polyphemus* it attains more than three times the relative weight of the latter and consumes nearly one-third less food. The difference is due to many factors, the most obvious being the difference in weight of the just-hatched larva, 1/2500 gram for the hornworm and 1/20th gram for the silkworm, which is an unfortunate selection as a basis for comparison. Actually, however, the data carried thus far means practically nothing, as the fully grown caterpillar is not an adult insect—it has merely attained its maximum growth.

Of the three caterpillars, one, "A", escaped when fully grown and lost its life in a battle with a lizard. The other two were reared to adult and from them the following data was obtained:

	'B'	"C"
Weight of pupa, February 2	2.541 gr.	3.0895 gr.
Weight of pupa, February 13	2.3155 gr.	2.8542 gr.
Per cent of daily loss	.842%	.672%
Computed weight of pupa at beginning	2.648 gr.	3.1965 gr.
Computed weight of pupa at end	2.1443 gr.	2.7044 gr.
Weight of pupal skin	.0346 gr.	.0344.gr.
Computed weight of meconium and H_2O loss	1.4105 gr.	1.6518 gr.
Weight of food eaten by larva	23.02 gr.	25 447 gr.
Live weight of adult	.6992 gr.	1.0182 gr.
Per cent of weight of food eaten by larva	3.02%	4.001%
Oven-dry weight of food eaten by larva	3.225 gr.	3.565 gr.
Oven-dry weight of adult	.277 gr.	.399 gr.
Per cent of weight of food eaten by latva	8.6%	11.2%
Ratio: Weight of adult to food eaten by larva	1: 11.6	1: 8.9
	a *male*	a *female*

The pupæ were not weighed daily as it was feared that the incidental disturbance might prevent the emergence of adults. The loss of H^2O from the pupæ was possibly abnormal, as they were not buried in moist soil, but kept in a closed glass container. The meconium, which consists of the non-gaseous by-products of the activities of the insect since the first day after it, as a fully-grown caterpillar ceased voiding excrement, is excreted by the moth immediately on emergence and was so scattered that it could not be weighed to separate it from the loss of water experienced by the moth in expanding and drying its wings, and the combined weight of these factors is determined by difference between pupa and adult plus pupal skin.

The computed maximum oven-dry weight of the larva is 2.15 times (2.15 for "B", 2.14 for "C") that of the adult; that is, the insect loses over half its dry weight in transforming from larva to adult. The final data showing that the oven-dry weight of the food consumed by the larva is approximately ten times that of the oven-dry weight of the moth, is only an approximation for the species, but even of two insects, gives a basis for comparison with other insects.

Mr. J. J. Davis has very kindly furnished the air-dry weights of adults of *Cirphis unipuncta* (ten museum specimens) as being approximately .048 plus grams. Ten weighed .489 gr., five weighed 235 gr. The air-dry weight of corn leaves from young plants is .02108 gr. per square inch, and .0311 gr. for leaves from mature plants of which the armyworms ate 41.4 square inches to complete their development, or from .872712 gr. to 1.28754 gr. The adult weighs only from 5.5 per cent or 1/18th, to 4.—per cent or 1/26 of this. Its larval period—26½ days—averaged one-sixth less than the hornworm, and obviously corn leaves are less nutritious for armyworms than tobacco leaves are for hornworms.

Indeed the results computed from Mr. Davis' data are so far removed from those on tobacco hornworms that it seemed desirable to determine how great are the variations in the amount of food eaten by caterpillars on different and the same host plants. In most of the feeding experiments which were subsequently conducted, only the last and the next to the last instars were used; the amount of food consumed in the earlier instars, small in any case, being usually computed from that eaten in the next to the last larval instar. The excrement and the portions of uneaten leaf were dried before weighing, to eliminate the error due to partial drying-out which appeared in the hornworm experiment.

Several larvæ of *Feltia annexa* Treitsche, a common cutworm of tobacco in Porto Rico, were used in the first experiment, but only one transformed to adult under the abnormal conditions involved.

Maximum gross Weight of larvae		Weight of food eaten while under observation		Excrement Dry weight	Digestibility of food
		Fresh	Dry		
1 ...	.807 gr.	3.891 gr.	.551522 gr	.175 gr.	60%
2.....	.767 gr.	4 517 gr.	.641414 gr	.253 gr.	60%
3	643 gr	5.582 gr.	.792644 gr.	361 gr.	55%
4	.87 gr.	(died)			

Larva number three transformed to an adult which weighed (dry) .064 gr., and its larva had eaten 3.746 gr. of fresh tobacco leaves, or .5244 gr., dry, or 8.2 times as much as the weight of the adult.

A larva of *Prodenia* sp., another less common cutworm of tobacco in Porto Rico, which attained a maximum live weight of 1.7 gr., ate 6.697 gr. (5.6253 gr. weighed and 1.077 gr. computed) of fresh tobacco leaves, or .93758 gr., but died in pupating. Other adults (air-dry) weigh about .1 gr., so its relation to food eaten is probably very much the same as of *Feltia*. Also, an approximately equal portion of the food which it ate was transformed into insect—55 per cent—as of the 5.6253 gr. of food weighed out to it, .36 gr. of dry excrement was obtained. The two cutworms were able to digest and assimilate 55 to 60 per cent of the tobacco leaves and produce adults weighing a little more than one-tenth as much as the food they ate. The hornworm caterpillars, which were able to digest only a little more than 40 per cent of the tobacco leaves, nevertheless produced adults which weighed about one-tenth of that of the food they ate.

A fresh cotton leaf was given to three larvæ of *Alabama argillacea* Hübner which had just molted to the last instar. In three days they had consumed practically all of it and spun cocoons to pupate. The amount actually eaten, after the weight of the stem and the fragments had been subtracted, equalled 4.0488 gr., or dry, .971712 gr. The total net weight of the caterpillars at the beginning of the instar was .2436 gr., and at the end .816 gr., a gain of .5724 gr., or 235 per cent, but this is only 14.1 per cent of the weight of the food eaten. The dry excrement weighed .6448 gr., thus the digestibility of the cotton leaf by these caterpillars is less than that of tobacco, or 34.7 per cent. The hornworms gained approximately 80 per cent of their weight in the last instar, but ate 85 per cent of their food at this time. The *Alabama* caterpillars gained 70 per cent of their weight in the last instar, and may be presumed to have eaten about 75 per cent of their food in this instar. On this basis, the total food eaten amounted to 1.3 gr. (dry weight) to produce three moths whose dry weight was .1025 gr., giving a ratio of moth to food of 1 to 12.6. The lower digestibility of the cotton leaf by the *Alabama* caterpillars necessitated a greater amount of it to produce a proportionate amount of insect.

A larva of *Laphygma frugiperda* S. & A., was able to digest only 25 per cent of tender corn leaves with which it was fed, and the adult (dry) weighed one-twentieth of the dry weight of the food that the larva had eaten. Comparing this data with the results obtained by Mr. Davis with the armyworms, which were also fed on corn, it appears that substantially similar insects feeding on the same host require relatively the same amount of food to produce adults.

More extensive experiments with fifteen larvæ of *Xylomiges eridania* Cramer and ten larvæ of *Bombyx mori* Fabricius, fed on the leaves of mulberry, with food and larvæ weighed after their first instar, give somewhat similar results. The caterpillars of the Noctuid, *Xylomiges,* digested 36 per cent of the somewhat dry and fibrous leaves of *Morus tartarica,* and ate 26.4 times as much food as their adults weighed. The silkworms digested 41 per cent of the tender leaves of *Morus alba,* and ate 23.8 times as much food as their adults weighed. The cocoons produced by ten caterpillars weighed 9.702 gr., of which the silk was 1.1195 gr., or 4.2 per cent of the weight of the food eaten. The weight of the moths (air-dry) was .601 gr., and of 1392 eggs, computed from that of unhatched eggs of previous generations, .599 gr., a total of 1.1 gr., for adults and eggs, or not so much as the weight of the silk. The digestibility of mulberry leaves by these caterpillars was greater than that of cotton and corn, but they ate considerably more of them to produce adults. Apparently it is true in only a rather general way that the amount of food required by insects is inversely proportional to its digestibility.

In the following table, the air-dry weight of the food of some other insects is compared with the weight of the adult, and the ratio between them given. None of this data is as accurate as might be desired, as the weight of all of the insects is plus the weight of food and excrement in the alimentary canal, and is not net as was that of the hornworm and of some of the other caterpillars.

The Amount of Food Needed to Produce an Adult Insect

Insect	Weight of adult in grams	Food or Host	Its weight in grams	Ratio
Hypera punctata Fabr	01552	3.08 sq. in. of clover leaves	.10297	1 7
Bruchus dominicanus Jekel	.00312	beans of *Acacia farnesiana*	02294	1 7.38
Tiphia transversa Say	.024	*Lachnosterna* white grubs	.27825	1:9
Tiphia spp (females)	0276			
Campsomeris dorsata Fabr male	089	grubs of *Ligyrus tumulosus* Burm	28	1·7
Campsomeris dorsata Fabr female	046			1·6
Elis haemorrhoidalis Fabr. male	006	grubs of *Phytalus apicalis* Blanchard	03562	1.6
Elis haemorrhoidalis Fabr. female	.018			1:3.-
Pyrgota undata Wiedemann	222	*Lachnosterna dubia* Sm.	.21	1:9
		Lachnosterna fusca Fr	.17	1:8
Ophion bilineatus Say	019	Caterpillars of *Feltia venerabilis* Walker	.1178	1.6.2

An additional source of error in the above data is that in the case of the parasitic insects which suck the juices from their prey, the weight of the chinitous exoskeleton of the host, which, strictly speaking, is not eaten, has not been subtracted from the weights given, and this would give an even lower ratio than is indicated. Thus, predaceous insects, which swallow their prey instead of sucking the juice out of it, presumably have about the same ratio as is given for the parasites in the table. The phytophagous insects also have about the same ratio when the food is leguminous, in which case it is a balanced ration, the crude fiber of the plants ingested being the equivalent of the indigestible chitin eaten by the predaceous insects. In the vegetative portion of non-legumes, the amount of protein present is much lower, and greater amounts of such food—roots, stems and leaves—must be consumed by the insect. The cell-sap of plants may form a perfectly balanced ration for some insects, as is indicated by the fact that the excreta of the leafhopper, *Kolla similis* Walker, even when feeding on the young shoots of sugar-cane, is clear, colorless, tasteless and devoid of sugar (5). Such an almost perfect consumption by an insect of the plant juices on which it feeds is due to its active habits. By contrast, the honey-dew excreted by aphids and mealybugs is an excess of carbohydrates which can not be assimilated by these sluggish insects because of their very rapid growth and lack of muscular activity.

Animal and plant juices may be almost entirely completely assimilated by most of the insects feeding on them, and they undoubtedly furnish food in its most digestible form. But the digestive apparatus of animals feeding on crude fibre is adapted to its digestion. The decaying plant tissue eaten by snails, slugs, millipedes and sowbugs, and the cow-dung inhabited by some of these animals and Elaterid and Threviid larvæ can be digested by them. One thinks of wood as being entirely cellulose, and entirely undigestible, yet the termite *Cryptotermes brevis* Walker, due to the protozoa present in its alimentary canal which dissolve the cellulose, can assimilate over half of some kinds of woods eaten by it. Of other, less preferred woods, it assimilates smaller portions (6), but this only further serves to illustrate the point that the digestive apparatus of animals is usually well adapted to digest the foods which they prefer and ordinarily eat.

The consumption of food by an organism has these purposes: (1) maintenance, (2) growth, (3) reproduction and (4) storage for any of the three. Some insects concentrate the consumption of food for all of these purposes into the larval period, while many continue to eat when adult for maintenance and reproduction, but growth for practically all is confined to the larval period. In a general way it is known that of the warm-blooded animals, those maturing most rapidly obtain a greater adult weight for the food consumed than those which mature more slowly, and the smaller animals require more for maintenance in proportion to their size, while cold-blooded animals require food for maintenance only in proportion to thair size and activity, but like the warm-blooded, inversely in proportion to their rate of growth. It is obvious that insects which develop slowly, such as white grubs and wireworms which may require three to five years to become adult in the northern United States, eat less per day in proportion to their size, but certainly consume more for maintenance because they live so long. Active insects with a rapid development, like grasshoppers, eat most per day, but make a less advantageous use of their food for growth than do other insects with about the same rapidity of development that remain quiet and consume less energy in voluntary activity, such as caterpillars. Insects which develop wings and heavy chitinization, and with a complete metamorphosis in their development, require more food for these structures and for the changes and losses involved in passing thru the pupal period, especially when this is protected by an extensive silken cocoon. The cocoons of *Tiphia* and *Bombyx* weigh somewhat more than the air-dry weight of the adults, and that of *Ophion* twice as much.

Two of the factors involved in the most economical use of foods for growth by insects have to do with the food, (1) the closeness with which it approximates being a balanced ration for supplying the needs of the insect, and (2) its digestibility. The others have to do with the insect, its rapidity of development, the amount of its activity, and the production of wings, scales, wax, heavy chitinization and similar structures.

Honey-dew and the nectar of flowers, altho not used for growth, are admirably adapted to the needs of adult insects with a high rate of muscular activity, such as butterflies, moths, flies, bees, wasps and ants. All of these insects in their larval stage, no matter what their food may have been, primarily required from it the proteids which were essential to growth. But as adults, carbohydrates, especially if in solution and readily available for assimilation, much better meet their needs. Insects which are not especially active as adults, such as most phytophagous and scavenger beetles, may continue to eat the same kind of food that was acceptable to them as larvæ, for the usually small proteid content of their food is now essential for reproduction. Most of the predaceous insects, such as dragon flies and the Carabid and Cicindellid beetles, are as active as any of those feeding on pure carbohydrates, but swift motility to capture their prey is essential, and is maintained despite the high proteid content of their food.

Many insects live for a long time as adults, the eggs of the female not maturing for some time after the emergence of the adult from the pupal stage. Such insects consume more food for maintenance as adults and for reproduction than they did as larvæ for growth. The clover-leaf beetle as an adult eats 4.76 square inches of leaves and "at least an equal amount of stem" (3) for maintenance, aestivation and reproduction, as compared with 3.09 square inches of leaves eaten by the larva for growth and maintenance. An Otiorhynchid beetle, *Exophthalmodes roseipes* Chevrolat, feeding on the leaves of sea-grape, *Coccoloba uvifera*, which have a digestibility of 42.6 per cent for this beetle, ate .399 gr. of the fresh leaf in four days, or about the equivalent of its own weight, .0982 gr., per day. However, as its dry weight was only 35.7 per cent of its live weight, and that of the tender sea-grape leaf only 19 per cent of the weight of fresh leaves, in a month the beetle would eat 16.2 times its own dry weight and such beetles in captivity at least, often live two or three months. The composition of the food, the length and activity of the life of the adult, the number and size of the eggs laid by the female all affect the amount of food which is consumed by the adult.

The amount of food required by an animal for growth, maintenance and reproduction varies so greatly and depends on such a large number of factors that for exact results it must be determined by direct measurement with individuals of the species concerned. But in a rather general way, it may be considered that the following classes of animals require approximately the amounts of dry weight of food multiplied by their own dry weight as indicated in the following table:

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THE FOOD PLANTS OF PORTO RICO

BY

O. W. BARRETT
AGRICULTURAL ADVISOR

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INTRODUCTION

Probably no other Tropical American country possesses so many distinct botanical species and subspecies of cultivated food plants as Porto Rico; in fact, few countries, even in the Old World, have so many—not counting forms and varieties of cereals, rosaceous fruits and potatoes.

Five hundred years ago this Island was perhaps the richest locality, except the Central Andean region, in the Western Hemisphere in the way of crop varieties; five thousand years before the conquest of the West Indies the aborigines of this country had undoubtedly partially domesticated a considerable number of food-producing plants and subsisted mainly by their cultivation.

Very likely many varieties of cassava (*Manihot* spp.), yautía (*Xanthosoma* spp.), yam (*Dioscorea* spp.) and sweet potato-like roots (*Ipomœa* spp.), utilized by the Arawaks and their forebears, had become extinct before the arrival of the Spaniards.

The U. S. Department of Agriculture, especially in 1915, made investigations to determine where the food plants of the Western Hemisphere originated, and, so far as possible, which species were domesticated by the prehistoric races. Briefly, it was found that the Central Andean region was for many centuries the center of a very artful though not strictly scientific agriculture; there the practice of terracing and irrigating small fields under very intensive cultivation and, presumably, rotation of crops over very long periods was *successfully worked out; and there more than 60 and probably over 80 distinct species of wild plants were domesticated and used* (nearly all of them, at least) *for food.*

From this old center the trend of plant dispersion was northward along the mountain ranges; some of the plants went up through Central America and were probably modified there more or less as time went on; in this class should probably be included the avocados, the squashes, some of the annonas and Capsicums, cacao, tobacco and perhaps some of the beans. Another dispersal route was eastward along the north shore of South America, thence along the chain of islands beginning with Trinidad and ending with Cuba; such plants as the pineapple, the edible canna, the Arracacha, the yuquilla, the jícamas, and probably some of the yams and yautías came here rather by this route than through Central America.

Porto Rico, situated approximately in the middle of the great chain of islands extending from Yucatán to Venezuela, might have received such plant introductions *via* either or both of these routes.

Not only Porto Rico but very probably Hispaniola, Cuba and Jamaica were large enough *per se* to have domesticated a few of their own wild plants and to have greatly modified some of those arriving from South America. According to archeological evidence the aborigines of Porto Rico had developed a fair degree of basic culture and were cultivating quite a number of crop plants contemporaneously with the Incas of Peru and other Andean races; and it may even be questioned whether the aborigines of Borinquen were not as successful in domesticating some of their wild plants as were the races of the Central Andean valleys.

The Arawaks and their ancestors, however, were not sufficiently insulated, as it were: they were continually exposed to the devastating attacks of their enemies from the South American shores, the Caribs and their forerunners As Cook and Payne point out, permanency of location and fixed modes of living are indispensable to agricultural development and social progress The Andean peoples, through their centuries of undisturbed, but very gradual domestication of plants *in situ* naturally excelled the inhabitants of more exposed regions.

The Carib races, the first recorded cannibals in history, presumably emigrating from some center in northern South America, played the part of marauders among the Antilles; possibly they brought a few crop plants to the islands but it appears more logical to accredit such good work to some earlier peoples.

As soon as the first Spanish colonists began to arrive, Governors made great efforts to introduce promptly those crops which they believed would be profitable to grow in Porto Rico, such as Sugar Cane, Ginger, Coffee, Tobacco, etc. The Coconut and the Bananas and Plantains also were brought in at an early date. Many vegetables and fruits came *vía* the Canary Islands, and soon such crops as Cacao and the Avocado came over from the Central American mainland.

During the seventeenth and eighteenth centuries there was probably comparatively little progress in plant introduction work here, but early in the nineteenth considerable efforts were made to establish those industries which might produce better revenues for the colonists, and in this it seems that Porto Rico shared about equally with Cuba and Hispaniola.

In 1890 there were established by Royal Decree of 1888 two Agricultural Experiment Stations; one occupied the present site of the Federal Experiment Station and was abandoned after several years of desultory operations; the other was started on a tract between Bayamón and Río Piedras; these Spanish Stations did some good work with the major crops, but their funds were entirely inadequate for complete success.

In September 1901 the U. S. Department of Agriculture established an Experiment Station in Río Piedras but the area was much too small for permanent location and in the spring of 1902 a tract was selected near the town of Mayágüez. During several years following 1902 a very large number of economic plants was introduced, mostly from the U. S. Department of Agriculture, and numerous exchanges were instituted with botanic gardens and experiment stations throughout the Tropics; in that way some 300 varieties of fruits, root crops, and vegetables were brought in and planted out. In 1903 a Coffee Sub-Station (La Carmelita) was established in the hills above Ponce, and there a great collection of coffees was amassed; but about 1910 the work was centralized at Mayagüez.

In 1910 the cane planters of the Island organized and established an Experiment Station at Río Piedras; this was taken over in 1914 by the Board of Commissioners of Agriculture; with the creation (by the Jones Act) of the Department of Agriculture and Labor of the Insular Government of Porto Rico, in 1917, the Experiment Station is now known as the Insular Experiment Station; it has been of considerable importance in plant introduction work, especially as regards sugar cane, avocados, grapes and bush berries.

In October, 1923 the Plant Propagation Station at Trujillo began operations and by the end of 1924 a considerable quantity of economic plants had begun to go out to the Model Farms and to the Agricultural Agents and farmers throughout the Island. During 1924 (calendar year) seven Model Farms were established; the foundations for breeding work have been laid and in the near future these Farms can be expected to become centers for food-plant distributions.

The purpose of this Bulletin is twofold:

First, to show the present economic status of every species of any considerable importance either as forage or food. Second, to give the origin of each species—both its original habitat and the country from which it was received into Porto Rico—and so far as possible, the approximate date of its arrival.

Soon after the American occupation a survey of the economic plants of the Island was made by O. F. Cook and G. N. Collins with the assistance of several other federal officers, and a bulletin * was issued which included all the known varieties of timber and forest trees as well as the edible fruits and the forage plants of the Island.

"The Botany of Porto Rico and the Virgin Islands", by Britton and Wilson, published by the New York Academy of Sciences as a part of that institution's "Scientific Survey of Porto Rico and the Virgin Islands", has been used as the basis of this list and its nomenclature has been closely followed with only one or two exceptions. The approximate percentage of indigenous species, as evidenced by the said "Botany of Porto Rico and the Virgin Islands", appears to be about 20 per cent. This is in line with the theory that Porto Rico has long been one of the most striking examples of a highly cultivated agricultural country into which economic plants have been brought from many other countries.

Obviously this is not a report upon Porto Rico's food-plant flora but merely a record of what is here and, so far as data are available from whence and when each species came. Of some horticultural groups, such as the beans, the cottons and the seasoning herbs there is a deplorable dearth of data; but such crops as the avocados, mangos, yams, yautías and coffees have been given special attention and it is hoped that the list of these crop varieties may serve as a standard for future reference.

Two special words to meet the exigency of this record have been brought in: *cormel,* the specialized horizontal rhizome attached to the central rootstock of yautías, dasheens, etc., *i. e.,* small corm, and *fecula,* the starchy substance which fills roots, tubers, etc.—on a par with the *pulp* of fruits: since there is no word for this in English, the Spanish word (which applies particularly to the dried substance of roots and starchy fruits) has been appropriated.

At present 496 species of food plants are in evidence in the Island. Of these, nearly, 225 fruits appear, of which 60 may be considered as first class. The true vegetables are rather few, only

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* "Economic Plants of Porto Rico", by O. F. Cook and G. N. Collins; 1904; pub. by the Smithsonian Institution, U. S. Nat. Mus. as contribution from the U. S. Nat. Herbarium, Vol 8, No 2

30 species; but the root crops are rather numerous (38); of seed crops there are 23 species and sub-species; and of salad plants there are 21. Forage plants, not including pasture grasses, amount to 43 species. The Island is well supplied with seasoning herbs—to the extent of 45 species. And there are at least 75 plants which do not correctly fall into any of the aforesaid groups.

While it must be admitted that this is a very respectable quota for a country no larger (only 3,435 square miles) than Porto Rico, it really is only *about one-half of what it easily might be.* For instance, there are today available in the Philippine Islands 175 species of fruits, which, so far as we are aware have never reached these shores. Besides these species there are *varieties* which in pomology and olericulture are just as distinct as the botanical *species:* another 200 or 300 *varieties* of citrus fruits, mangos, bananas, plantains, etc., which could and should be introduced at once. Our quota of mangos and avocados is a matter of great credit, but in the line of citrus fruits the Island is far behind its due quota.

No attempt has been made to give detailed suggestions regarding the propagation or uses of the 700 or more varieties listed in the following pages; however, effort has been made to awaken interest in certain food plants which most certainly deserve better attention, and to make the text readable for the layman.

Unfortunately no good photographs are available to illustrate the most interesting indigenous, not to say endemic, food plants of the Island.

In all works of this kind errors are bound to creep in. Moreover, the omission of certain species which, to some individuals perhaps, will appear ill-advised has been allowed, while certain other plants which, from some points of view, should hardly appear in a work of this kind, are included.

Assistance in revising parts of the text and the nomenclature has very kindly been given by Dr. N. L. Britton, Director of the New York Botanical Gardens, and the prime mover in the "Scientific Survey of Porto Rico and the Virgin Islands". Mr. C. A. Figueroa, Assistant Agricultural Advisor of the Department of Agriculture and Labor, has furnished data on Sugar Cane and the dates for some of the early introductions. Mr. T. B. McClelland, Horticulturist of the U. S. Experiment Station, has also rendered assistance.

THE FOOD PLANTS OF PORTO RICO

ACEITUNA; Olive; *Olea europea* L.

This very important European fruit was introduced by the Spaniards in the early days of the Colony but did not succeed. At present only a few specimens are in evidence at the U. S. Experiment Station. Whereas this species might be grown with some success on the higher and drier districts, it is of course useless to consider it as a food crop of the Island. Probably some of the largest specimens of the species (1.5 m. or more in diameter) are still in evidence in Central Mexico and while it has been fruited at sea level in the tropics (in the Jamaica Botanic Gardens) it always has been an extra-tropical species.

ACELGA; Chard, or Leaf-Beet; *Beta vulgaris* var. *Ciola* (L.) Moq.

This first-class European salad vegetable succeeds well; two or three varieties are becoming fairly common.

ACHICORIA; Chicory, Succory; *Cichorium Intybus* L.

A rather rare old European kitchen vegetable occasionally planted in the interior of the Island; apparently not adaptable to the warmer regions of the coast.

ACHIOTE, Achote; Annatto; *Bixa Orellana* L.

This very important shrub or small tree, native to Tropical America, is now naturalized and cultivated throughout the Tropics of both Hemispheres; while usually it begins to bear at the height of 2 m., it occasionally reaches 9 m. It is one of the commonest of the so-called minor crops in Porto Rico. The following 5 varieties are recognized, and their coloring-material percentages are as follows:

Pelón ----	**6.80% to 8.73%**
Colorado--	**7.96%**
Amarillo--	**6.69%**
Blanco ---	**5.80%**
Negro	

The last is of too little value to pay for collection although it is sometimes used to adulterate the better varieties. At the Trujillo Plant Propagation Station hundreds of plants of the better varieties have been propagated for general distribution, and in many instances the Agricultural Agents have obtained large quantities of selected seed from certain districts famous for their excellent product; in the near future the results of these plantings will be apparent. Fortunately, during the past two years the price of Achiote has been very high in the mainland, due to interstate laws which prohibit the sale or transportation of certain dairy products if colored with chemical dyes, thus obliging certain producers to use vegetable coloring materials instead of cheaper chemicals.

The total production of Porto Rico today is probably in the neighborhood of 150 tons per annum. Weekly shipments in season (January to April) may amount to over 41,000 pounds.

Selective breeding experiments have been started at the Trujillo Plant Propagation Station and the Model Farms with the purpose of eventually securing extra-high-grade varieties, which will bring an extra price on the mainland market. At present, there is no export of the paste which is made by boiling the seeds and drying the separated powdery aril in sheets or cakes.

Really enormous quantities of Achiote are consumed locally; almost every plate of rice (say, 1,000,000 per day) and many other dishes such as beans, stews, soups, etc., eaten in the Island are colored with Achiote.

ACTINIDIA; Yang-Tao; *Actinidia arguta* Miq.

An interesting fruit vine recently introduced from the mainland; habitat, eastern Asia. The fruits are about 3 mm. in diameter, roundish, greenish yellow and very sweet, with a peculiar perfume.

ADLAY; *Coix Lachryma-Jobi* L. var. *Mayuen* Stapf.

Six varieties of this common Philippine crop were introduced in 1923 through the Plant Propagation Station at Trujillo Alto. Four of these forms made a phenomenal growth; in some instances one seed produced a *"cepa"* of some 50 or more suckers, most of which attained a height of 1.5–2 m. with many culms bearing heavy "heads" of large seeds with only a moderately hard "shell". These seeds are good poultry feed, better if cracked. Bread can be made from Adlay flour with one-third to one-half wheat flour added. The yield of grain, under good conditions, is heavy; and according to P. J. Wester, Agricultural Advisor of the Philippine Bureau of Agriculture, it is a promising grain for the Tropics, he records yields of 1,634 to 3,625 kilos of grain per hectare.

AGUACATE. See **Ooyo.**

AGUACATE DE CARACAS; Caracas Avocado; *Persea sp.*

Perhaps the rarest of all the known Avocados. Four seeds were obtained in Caracas, Venezuela, in November, 1924, and planted at the Trujillo Plant Propagation Station.

The fruit, of medium size, flavor, and apparent value is very distinct as to shape; the distal end, rounded in all other species, is prolonged into a tapering short beak; the "neck", too, is different in that it is rather strongly curved and its basal portion is larger (in diameter) than the middle part.

This has been described, according to Dr. H. Pittier, of the Museo Comercial of Caracas, as a new species.

AGUACATE DE GUATEMALA; Guatemalan Avocado;* *Persea Persea* (L.) Cockerell.

This race is practically a sub-species and is distinguished from the West Indian race by the thick rind of the fruits, and while the foliage lacks the anise-like odor of the Mexican species the young leaves are usually deeper colored (reddish) than those of the West Indian type. The fruits, with their firm thick peels, will undoubtly stand long shipment better than the ordinary West Indian varieties; their color ranges from light green to purplish black; the surface is often rough, which is a disadvantage in the retail trade.

The following varieties have been introduced, partly at the U. S. Experiment Station at Mayagüez and partly at the Insular Experiment Station at Río Piedras:

Blakeman. Originated at Hollywood, California, in 1912; skin thick and woody, granular. Dark green with numerous yellowish or reddish brown dots. Pulp rich and pleasant and of high quality.

Dickinson. Originated at Los Angeles, California, in 1912. Skin very thick and brittle but separating readily from the flesh; dark purple with irregular maroon dots. Pulp buttery, of pleasant flavor.

Lyon. Originated at Hollywood, California, in 1911; pear-shaped, sometimes with a short "neck"; weight 400–600 grams; skin rough or undulating, green with yellowish or brownish dots, moderately thick, granular; flesh smooth, firm, light colored, fiberless, unusually rich.

Sharpless. Originated near Santa Ana, California, first propagated in 1913; shape pyriform, sometimes with quite a long "neck"; size large to very large (450–700 grams); skin slightly roughened or pitted, glossy greenish purple to deep purple, with numerous yellow dots; skin thick, frequently granular, or even woody; pulp smooth, firm, fiberless, of excellent quality.

Solano. Originated at Hollywood, California, first propagated in 1912; shape oval or obovate, size medium to large; skin nearly smooth, glossy, bright green with numerous yellowish dots; skin moderately thick; pulp smooth, yellowish green, fiberless. Quality not so good as most of the other Guatemalans but the tree is quite productive and the season —March to May—in California, and October to November in Florida—which means that it will probably be a winter bearer in Porto Rico.

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* The correct name for this fruit is O (in the Quekchi language), On (Maya dialects), or Oj (pronounced Okh) in Guatemala

Spinks. Originated at Duarte, California, in 1915; shape regular; size extremely large (500–1,000 grams); skin thick and woody, dark purple; pulp firm, smooth, rich, yellow, fiberless and of excellent flavor.

Taft. Originated at Orange, California, in 1912; shape regular, with short "neck"; skin thick but not brittle, deep green with yellowish dots; flesh firm, light yellow, fiberless, unusually rich and pleasant.

Taylor. Originated at Miami, Florida, in 1914; shape pyriform to obovate; skin moderately thick, granular, dull green with yellowish dots; pulp firm, fiberless, of good quality.

Akbal. Elongated to slender pyriform, sometimes curved, size medium; surface quite smooth, bright green; skin very thin, firm; flavor nutty, good.

Benik. Obovoid or broad pyriform, very large; skin pebbled, deep purplish maroon, thin, pliable; pulp of excellent flavor.

Cabnal. Quite round, medium-sized; surface pebbled, dull green; skin thick, woody; nutty flavor, fairly dry.

Cantel. Oblate, medium-sized; deep yellow green with yellowish dots; skin medium; seed very small.

Coban. Pyriform or obovoid, above medium size; skin nearly smooth, deep green with few small yellowish dots; excellent, rich flavor.

Collins. Small, rough fruit, pyriform, dark green; of Floridan origin.

Chabil. Round, smallish; surface smooth, deep dull purple, with few large yellowish dots; skin thick, unusually woody; pulp slightly fibrous, flavor nutty.

Challenge. Nearly round, good size; rough surface, skin granular, dark purple; seed large, tight in cavity; originated in Hollywood, California.

Chisoy. Roundish, large; skin pebbled, yellowish or dark green, dotted yellow; very oily, pleasant flavor.

Grande. Oblong, large; skin thick, leathery, dark purple. From Puebla, Mexico, via California.

Ishim.—Pyriform or oblate, below medium in size; surface smooth or pitted, dark maroon-purple; skin thin, tender.

Ishkal. Small, nearly round; skin rough; thick, purple with few large yellowish dots.

Itzama. Pear-shaped; surface pebbled, skin glossy green; very late.

Kanan. Round, large; surface pebbled, bright green with few large yellowish dots; skin medium, brittle; quality good.

Kanola. Roundish, small, deep purple with small yellowish spots; flavor oily; skin 3 mm. thick.

Kashlan. Oval, very large (0.6 kilo or more); skin deep green with numerous large yellow dots.

Kayab. Obliquely spherical, medium to very large; surface pebbled, deep or yellowish green; skin thick, hard and woody.

Kekchi. Pyriform or obovoid, small; surface rough, deep dull purple maroon with few small brownish dots; skin thick, woody, few fibers.

Knight. Round, of good size; skin rough, green, woody; flesh with a nutty flavor, carrying 20 to 25 per cent of oil.

Lamat. Oval, medium to large, deep green with a few yellowish green dots; rich flavor.

Linda. Round, large; skin rough, purple, woody; pulp rather dry with only 13 to 16 per cent of oil, fiberless.

Manik. Oval to elliptic-pyriform, about medium in size; surface bright green; skin medium, hard; flesh, rich, unusually dry

Mayapan Round, medium-sized; surface decidedly rough, greenish purple to dull purple with many large yellowish dots; skin very thick (5 mm. near the base) and granular; quality excellent.

McDonald. Medium-sized, round, dark mahogany color; originated in Hawaii.

Nabal. Round, below medium in size; skin pebbled, rough, dull green.

Nimlioh. Broadly oval, one of the largest (1–2 kilos); skin pebbled, deep green with many large irregular yellowish dots; excellent flavor.

Panchoy. Round or obovoid, medium to large; surface heavily pebbled, green with yellowish dots; one of the very best sorts.

Pankay. Pear-shaped, long, medium-sized; skin smooth, light green.

Queen. Oblong-pyriform, good size; skin rough, deep purple, thick; flesh excellent, not very oily.

Schmidt. Pear-shaped, large; skin fairly smooth, green; late.

Tertoh. Oblong to slender pyriform, extremely large (1 kilo or more); length up to 20 cm.; surface smooth, deep dull purple with russet dots and patches; skin medium, woody; seed very small.

AGUACATE HIBRIDO; Hybrid Avocado; *Persea drymifolia* X *Persea Persea.*

Thus far the principal hybrid in cultivation is known as the *Fuerte* and this bids fair to be one of the most popular varieties of

Avocado in the Island; one plantation near Villalba has already many Fuerte trees in bearing and many are being propagated in nurseries.

The fruit is pyriform, with no "neck", or oblong; size medium to large (300–500 grams); surface decidedly rough, sometimes wrinkled, dull green with numerous small dots, about 1 mm. thick, separating from the flesh, and leathery. This fruit is probably one of the richest fruits in the world in fat content; some fruits analyze as high as 30 per cent, yet the flavor is not seriously affected by this exceedingly high percentage of oil.

> *Winslowson.* This is a seedling from the Winslow "which appears to have been hybridized with a West Indian variety, as it more resembles Trapp than it does Winslow." Fruit immense (1 k. or more), round, dark green, very shiny. Season November–December. Said to be prolific and a precocious bearer.

AGUACATE DE LAS INDIAS OCCIDENTALES; West Indian Avocado; *Persea Persea* (L.) Cockerell.

The varieties of the so-called "native" Avocados of Porto Rico are descendants almost entirely of the trees brought to the Antilles from Central America or Mexico. They resemble the Guatemalan race, but the young leaves usually are not reddish and the rind of the fruit is leathery and thin instead of thick and woody.

While it must be considered as one of the most important food fruits of the Island it is very rarely planted in orchards. The 1920 census indicated that approximately 161,000 "native" trees are in evidence here; only 95,000 of these were "in bearing". Several nurseries for the propagation of budded varieties have been established in or near the Bayamón district, the actual number of Avocado trees here now is probably not less than 200,000 and may exceed 250,000. Thousands of seedlings have been raised for stocks, mostly at the Trujillo Plant Propagation Station, but also at the Model Farms and the Río Piedras Experiment Station; in well-cared-for rows a good seed will produce a 3– to 5–meter stock in about 12 months.

Practically all the "native" varieties here have a green skin and more or less "neck"; the pulp is nearly or quite fiberless; the seed is variable. The oil content is moderate—from 10 to 20 per cent. Oil made at the By-Products Plant in Mayagüez, by first dehydrating the nearly "mellow" ripe pulp and then pressing, has a very strong, dry (*sic*) taste; and the "cake" (after expressing the oil) at the said Plant appears to be exceedingly nutritious.

A fertiliser, also made at the said Plant from the sliced, dried, and ground seeds has been used with good results at the Model Farms and Trujillo Plant Propagation Station; this could probably be used as a goat feed.

Over 150 barrels of seeds for nurseries in Florida were exported in 1924. Practically no fruits have been exported thus far; the thin peel of the "native" fruit is too easily damaged en route. Orchards containing West Indian, Mexican, Guatemalan, and Hybrid type trees are in evidence at Villalba, Garrochales, Trujillo, and Bayamón.

Hayman. One of the few "native" sorts which seem worthy of a name; fruit large, roundish; from a Mayagüez tree.

Pollock. An extremely large fruit (weight commonly 0.75–1 kilo, but occasionally attaining 1.5 k.), smooth-skinned, light yellowish or green, fiberless; flavor rich, very pleasant, rather dry; originated at Miami, Florida, and first propagated in 1901.

Trapp. This very interesting and quite distinct variety originated at Coconut Grove, Florida, in 1901; of very unusual shape (roundish oblate); size large to very large (400–600 grams; surface nearly smooth, pale yellow green with numerous yellowish dots; one of the latest-bearing avocados known—fruits frequently remaining on the tree until February or even March. Should, perhaps, be separated as a sub-species.

Waldin. A new Avocado originating at Homestead, Florida, in 1915; size large to very large (weight 400–700 grams); shape oblong to nearly pear-shaped; skin smooth, tough, without markings; flavor rich, with very little fiber; season October to January.

AGUACATE DE MEXICO; Mexican Avocado; *Persea drymifolia* Cham. and Schlecht.

This species is readily distinguished from the West Indian and Guatemalan types by the peculiar odor of its leaves which remind one of anise when they are bruised; the skin, moreover, is comparatively very thin, in some races being almost papery and never exceeds 1.5 mm.; there are also peculiarities in the flowering and fruiting habits of this species.

Their cultivation here, which was begun several years ago, will probably result in the extension of the fruit shipping season; this species therefore, in connection with the Guatemalan race of the common West Indian species, and the hybrids between these two or three groups should theoretically carry the crop season over nine if not eleven months of the year.

The following varieties have been introduced at the Río Piedras Experiment Station and the Trujillo Plant Propagation Station:

Gottfried. One of the largest of this type; pear-shaped, purplish black; skin peels readily; pulp nearly fiberless, of good flavor.

Northrop. Originated near Santa Ana, California, in 1911; shape regular, sometimes "necked", very small (150–250 grams); skin smooth, very glossy, deep purple, membrane adhering close to the flesh; pulp buttery, fiberless, of good quality.

Puebla. Originated at Atlixco, Mexico, propagated in 1911 in California; shape regular, size rather small 250–300 grams; skin smooth, glossy, dark maroon purple with numerous reddish dots, fairly thin but removable from the flesh, pulp yellow, buttery, of a distinctly nutty flavor and high quality

AJI CABALLERO; Devil Pepper; *Capsicum annuum* L.

Very common, semi-cultivated variety producing over a long period, extremely pungent, minute fruits from 5–8 mm in diameter, conical or roundish Plant 1–1.5 m Ripe fruits dark red; used generally while green.

AJI DULCE; Sweet Pepper; *Capsicum annuum* vars.

An undetermined race having wrinkled, nearly globular, sweet, mildly aromatic fruits about 1.5–2 cm in diameter, is common in some districts; 3 forms of this were brought from St. Thomas in March, 1924. This appears to be the best sort for pickling, and could be exported fresh or dried if a market were opened. A rare long-conical form with a white or flesh-colored skin is in evidence at Trujillo Plant Propagation Station; origin unknown

AJI GRANDE; Red Pepper, Chilli, Long Cayenne; *Capsicum annuum* L. var *acuminatum* Fingh.

A very common old race of Peppers, widely cultivated throughout the Island. The true type of this botanical variety has long red fruits curved at the tip and very "hot". A similar variety, *longum* Sendt., has large leaves and fruits (of several colors); another, *fasiculatum* Irish, bears the red fruits in clusters

Most forms of these races succeed well here. Their culinary uses are more restricted here than in Mexico and Central America.

AJI PEQUEÑO; Tabasco, or Short Cayenne Pepper; *Capsicum annuum* L. var. *conoides* Irish.

The smaller varieties of these Cayennes are semi-cultivated on a very small scale, but are widely known. The intensely hot red fruits are erect, 1.5–2.5 cm. long, and nearly cylindrical.

A similar variety, *cerasiforme* Irish, has very small (3–4 mm.) roundish fruits.

Both these races are used in making "pepper sauces" with vinegar and in seasoning soups, meats, etc.

AJO; Garlic; *Allium sativum* L.

A fairly common vegetable, 20–30 cm. The domestic bulbs are from one-fourth to one-half the size of the imported (*ex* S. Europe) article, but command a fair price in the local markets.

Native of Southern Europe.

AJONJOLI; Sesame, Bene; *Sesamum orientale* L.

This fairly common crop, native to the Old World Tropics, is cultivated in various areas of the interior but always on a small scale and the grain is only used for local consumption. Only one variety is in evidence; 1–1.25 m. The seed is used in various dulces, horchatas, and even raw.

AKEE; *Blighia sapida* Koen.

Several mature trees of this African species are in evidence here and seedlings are being propagated as rapidly as possible. The fruits appear to be as large or larger here than in Jamaica or any of the other West Indian countries The fruit is quite unknown to the agriculturists thus far. Introduced about 1904.

ALBAHACA DE LIMON; Basil; *Ocimum Basilicum* L.

This old culinary herb of uncertain origin endures ordinary situations well; 20–40 cm Not commonly cultivated as an aromatic condiment but it deserves a place in every garden

ALCACHOFA; French Artichoke; *Cynara Scolymus* L.

This old European vegetable of uncertain origin has been occasionally cultivated in several gardens here but it is not on the market. Since two years are required for the full development of the plants, there is a small chance for the successful cultivation of this excellent vegetable here

ALCACHOFA; Jerusalem Artichoke, Girasole; *Helianthus tuberosus* L.

This very interesting and potentially important root crop was long cultivated by the Indian races of Canada and the Central United States. Whether there were distinct varieties of this species in pre-Columbian days is not quite certain but there is no doubt that two or three similar species (especially *H. giganteus* L.) were used for food by the aborigines of the said region probably for centuries before the arrival of the European colonists. There are today four or five distinct varieties and probably several other forms and races of this species. In Egypt it has long been grown as a major crop in some sections under the name of Topinambour. It was introduced through the U. S. Experiment Station at Mayagüez in 1904 but does not seem to have become thoroughly acclimated at that time. In 1923 it was again introduced at the Trujillo Plant Propagation Station; the first crop, without being thoroughly rested, was immediately planted in the same plats, and the second crop gave splendid plants from 2–3 m. in height some of the "hills" yielding as much as 8 kilos of tubers. The average yield per hill is perhaps less than 2 kilos.

Orders are coming in from farmers who have seen this crop growing on the Model Farms and it is hoped that in the near future this will be one of the commonest crops on the small farms.

The small stems, leaves and flowers are excellent forage for domesticated animals while the very sweet tubers are excellent for pigs and cattle. Recently sugar has been made from the tubers which contain about 18 per cent of inulin and sugars, instead of starch; this inulin is easily changed into levulose and by a new process with lime compounds a calcium levulate is formed which can be reduced to levulose *crystals*. Therefore, if a crop of 1,000 bushels per acre (which seems to be quite possible) *can* be produced, the amount of sugar obtainable from one acre of Girasole may compare very favorably with the amount obtainable from sugar cane

ALCACHOFA DEL JAPON; Chorogi, Chinese- or Japanese-Artichoke; *Stachys Sieboldi* Miq.

Recently introduced through the Trujillo Plant Propagation Station from Japan *via* France Tubers about one-fourth to one-sixth the size of the "Jerusalem" Artichoke. Presumably adapted to loose soils at moderate elevations

ALCARAVEA; Caraway; *Carum carui* L.

This European herb is adapted to the higher districts; it seeds at Trujillo but does not endure well the droughts The Wholesomeness of its leaves, roots, and seeds, as aromatic condiments, entitles it to a place in every kitchen garden.

ALFALFA; *Medicago sativa* L.

This strictly temperate European forage plant does not endure this climate well. In limey soil it sometimes reaches a height of 1 m. and flowers but does not form thick stools. Its culture should be abandoned here.

ALGALIA; Muskseed; *Abelmoschus Abelmoschus* (L.) Cook & Collins.

A rather rare vegetable, sometimes cultivated for the seeds which have a strong odor of musk.

ALGARROBO; West Indies Locust; *Hymenaea Courbaril*, L.

Native tree, 10–20 m. Never cultivated, but common. Floury aril surrounding the large seeds is malodorous but edible and apparently quite wholesome. Very common in markets.

ALGODON; Cotton.

The cottons of Porto Rico require careful study. Their multiple origin and the three or four centuries of inter-breeding have tended to "blend out" many of the original specific characters.

The Arawaks had Cotton, probably in several varieties, under at least partial cultivation. Spain not only gave her own varieties and those of the Canary Islands but brought hither the Mexican and probably the Peruvian and other Central American, South American, and Antillean varieties; the slave ships brought over varieties from West Africa; and finally some of the United States varieties arrived. Large lots of seed from St. Kitts and Antigua have recently been imported for the long-staple "Sea Island" planters.

ALGODON DE BARBADOS; Sea Island Cotton; *Gossypium Barbadense* L.

This probably indigenous shrub is rapidly becoming one of the principal crops of the Island; the present production is about 1,500 to 2,000 tons of seed cotton; some considerable percentage is damaged by contact (hybridizing) with short-staple "native" cottons. The principal districts are the northwest, the southwest coastal plain and scattered areas over the north central and southern districts. There are few large fields, one or two acres probably being the average.

One cottonseed oil-factory was started in 1923 and this plant has consumed practically every pound of seed since its opening, whereas previously the Porto Rican cottonseed was exported to British West India Islands and to European countries.

The oil is not used here for human consumption; the meal produced at the seed plant is sold both as a cattle feed and feltiliser but in the future it is expected that most of the meal will be turned into dairy feeds. Several hundred tons of meal are brought from Venezuela and about the same quantity from the United States.

ALGODON DEL PERU; Peruvian Cotton; *Gossypium* [illegible]

A small rare cotton formerly cultivated and [illegible] "[illegible]".

ALGODON DE PUERTO RICO; **Porto Rican Cotton, Bourbon Cotton**; *Gossypium purpurascens* Poir.

This very rare species is never cultivated as a food plant but it has some points which might make its extensive culture of advantage: it attains a height of 6 meters. Absolutely perennial and produces a heavy crop of large smooth seeds.

ALGODON DE RIÑON; **Kidney Cotton**; *Gossypium brasiliense* Macfad.

A small rare short-staple variety of cotton; according to Britton & Wilson, "spontaneous after cultivation". The seeds are easily separated from the bright white fiber.

ALGODON SILVESTRE; **Wild Cotton**; *Gossypium hirsutum* L.

A shrub or small tree 2–4 m.; seed very "fuzzy". According to Britton & Wilson, "spontaneous after cultivation".

ALMENDRILLO; **Wild Plum**; *Laurocerasus occidentalis* (Swartz.) Roem.

Wild tree, 10–18 m., in moist forests; fruits 2–2.5 cm. long. Valued for its excellent timber.

ALMENDRO; **Tropical Almond**; *Terminalia catappa* L.

One of the commonest shade trees in Porto Rico; 6–20 m. This species is almost deciduous though some trees remain leafless but 2 or 3 weeks. The nut is of very little value, though frequently eaten by children. The pulp of the thoroughly ripe fruit, although very astringent, is also eaten by children. The fibrous cover of the kernel militates against the use of the nut commonly. Practically no variation occurs here; some fruits are much redder than others but this is undoubtedly a non-specific character

ALLSPICE. See **Pimienta.**

ALOCASIA. See **Panamá.**

AMATUNGULU, Tungulu; **Natal Plum**; *Arduina grandiflora* E Meyer.

A first-class fruit shrub, 2–6 m.; introduced some 25 years ago; from South Africa. The elliptic or ovoid, pointed, dark red fruit, 3–5 cm. long, with white or red-streaked pulp is used like strawberries, fresh or cooked. Distributing by the Department. Probably exportable.

AMATUNGULU, Tungulu; **Natal Plum**; *Arduina bispinosa* (L.) Desf.

"Very similar to the larger *Arduina grandiflora*, but distinguished by its small flowers and small roundish fruits; introduced about 1903 from South Africa, via U. S. Department of Agriculture.

AMIGLI; *Annona senegalensis* Pers.

Recently introduced third-class West African fruit tree, 3–10 m. At Experiment Station at Río Piedras.

ANIS; **Anise**; *Pimpinella Anisum* L.

This old Levantine culinary herb is rarely grown though it endures the climate very well. The name is applied also to several other aromatic herbs.

ANISE. See **Anis.**

ANNATTO. See **Achiote.**

ANON; **Sugarapple**; **Sweetsop**; *Annona squamosa* L.

First-class fruit tree, 3–6 m.; cultivated in all districts but not so common as in other West Indian countries; main crop, September to May. Slight individual tree variation, but no distinct varieties recognized by name. Used only as fresh, dessert fruit; unsuited for export. Probably native; aboriginal name, Hanon.

ANONANG; **Philippine Plum**; *Cordia blancoi.*

Recently introduced second-class fruit tree from the Philippines at the U. S. Experiment Station.

APIO; **Celery**; *Apium graveolens* L.

A difficult vegetable for tropical olericulturists; it grows fairly well here in the wet season, especially in the higher districts, but blanching is seldom successful.

APIO. See **Arracacha.**

APIO-NABO; **Celeriac**; *Apium garveolens* DC. var. *rapaceum* DC.

Like celery, this plant does best in cool, moist regions; if rapidly grown the root has little or no fiber and no bitter taste. Should be grown more extensively.

APPLE. See **Manzana.**

APRICOT, Santo Domingan. See **Mamey.**

ARRACACHA; **Apio**; *Arracacia xanthorrhiza*, Bancr.

A first-class vegetable fairly common on the north side of the Island. Probably introduced in pre-Columbian times from Venezuela. It succeeds best in the moist rich limey soil of the hills. Probably never flowers here; propagated with offsets from the old root-cluster. Especially good in stews and soups; served alone, boiled or fried, its strong flavor (resembling that of celery, parsnip, carrot, and squash) is rather too rich for most palates; odor rather unpleasant. Old roots may be left in the ground for years, portions being broken off as required at any season of the year—an advantage possessed by extremely few vegetables. Worthy of much more extended cultivation; unfortunately, few people seem to be acquainted with its use, and is less common now than formerly.

ARROWROOT. See **Yuquilla.**

ARTICHOKE. See **Alcachofa.**

ARROZ; Rice; *Orysa sativa* L.

This very old East Indian cereal was introduced in the early days of the Spanish colonists. Three or four varieties are cultivated, mostly in the hilly districts; according to report over 11,000 acres are planted here and the outturn is estimated at some 2,500 or 3,000 tons—a small percentage of the total amount of this grain consumed here: 80,000 to 90,000 tons is about the average annual import.

Irrigation and the flooding method commonly practiced in Oriental countries are almost unknown here. Tests of many standard varieties from the Mainland and the Orient have given negative results in practically every instance.

ASPARAGUS. See **Espárrago.**

ATEMOYA; *Annona squamosa* X *A. Cherimolia.*

Seedlings of this very interesting hybrid fruit are being propagated at the Trujillo Plant Propagation Station; seeds presented by Mr. P. J. Wester, Agricultural Advisor of the Philippine Government. The Atemoya has fruited for 10 years in the Philippine Islands and is one of the best of several *Annona* hybrids created at the Lamao Plant Breeding Station by Mr. Wester.* Seedlings vary somewhat.

AUSU. See **Malagueta.**

AUSUBO; *Sideroxylon fœtidissimum* Jacq.

Indigenous tree common in all the old forests of the Island in both the wet and dry districts; 20–30 m.; fruit a yellow berry, roundish or oval, 2–2.5 cm. long, containing one or two large seeds and a small amount of acid or sweetish yellow pulp.

AVENA; Oats; *Avena sativa* L.

Rarely cultivated. Native of Old World. Leaves and inflorescence commonly attacked by rusts.

AVOCADO. See **Aguacate.**

AVOCADO. See **Coyo.**

BACULO. See **Gallito.**

BALM. See **Melisa.**

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* At Lamao, Bataan Province, across the Bay from Manila is assembled the world's largest collection of tropical fruits—some 500 varieties.

BALSAM APPLE. See **Cundeamor.**

BANANA. See **Guineo.**

BARBASCO. See **Canela de Costa.**

BARLEY. See **Cebada.**

BASIL. See **Albahaca de Limón.**

BATATA,* Camote; Sweet Potato; *Ipomœa Batatas* (L.) Lam.

This, the principal root-crop of Porto Rico (as well perhaps, as of all other tropical countries) was probably in cultivation by the very early aborigines; an illuminant fact is the presence of the wild species (*Ipomœa tiliacea* Choisy) from which this tremendously important cultigen is descended. Cultivated much more widely and extensively than any yam, yautía or yuca. Not all the types are in evidence here to day; the *Bush* (non-repent) form and the very long-rooted form, with a beautiful purple fecula, from Eastern Mexico appear to be absent.

In June 1924, some 240 varieties of named seedlings were presented by the Agricultural Experiment Station at Christiansted, St. Croix, A. V. I.; and these have been tested at Vega Baja Farm and San Sebastián Model Farm and the Río Piedras Experiment Station. About 150 of these varieties were discarded in 1925 as unworthy of further test. These seedlings, produced by Mr. J. B. Thompson, in charge of the said Station, were raised from several mainland and several West Indian standard varieties; in most cases only the female parent was known (— some may have been self-fertilized). The forms exhibit all gradations from white, through yellow, to dark-rose-colored feculas, while some show rays and clouds of purple on a white background; the leaves are of many types. In dry situations some plants produce seed here, but propagation is always by vine cuttings—except when a rare root may be used for sprouts.

Seeds were also received during 1924 from the said Station, and these were grown at the Trujillo Plant Propagation Station, the seedlings being distributed mostly to the Vega Baja Farm; some fifty varieties were raised and are now under test; seedling work both at Río Piedras and U. S. Experiment Station has not given to date very good results.

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* Just where the wild species was domesticated is probably impossible to determine; however, the Quichua dialect, which was spoken by the Incas in 1500, contains several words which apply only to *Ipomoea Batatas*; the word *Cumara* was given to the sweet potatoes of the dry, or starchy, type, and *Apichu* was the general term for the varieties having a sweet, or moist, fecula. Presumably, distinct varieties had their own names. It must be admitted as an important horticultural fact that the Incas recognized *two classes*, or sections, of this crop—something which has scarcely been done since.

Some forty varieties of sweet potatoes of the Mainland have been introduced at the United States Experiment Station; of these the following are, in order of importance, the best for local conditions:

Key West, locally known of late and now planted as "Cayo Hueso": prolific and early.
Madeira, of unknown origin; a splendid sort.
Porto Rico, of uncertain origin; very popular in the mainland.
Southern Queen.
Golden Beauty.
Creola.

Other Mainland varieties recently presented by the United States Department of Agriculture and now under test by this Department are, in order of importance:

Nancy Hall.
Pumpkin.
Yellow Jersey.
Triumph.
Dooley.
Big Stem.

The vines are not used here (as in the Philippine Islands) as a spinach substitute; they are often fed to pigs, however.

An excellent feed is made from the small (cheaper) entire roots, and a rich flour for human consumption from the fécula.

The following old native varieties deserve brief mention:

Ahoga-Perro. A rare variety, common near the east end of the Island. The roots are so dry that, it is said, "even dogs choke in eating them."
Almacenada. The white fecula has purplish veins. The skin may be red (*Almacena colorada*) or white (*Almacena Blanca*).
Anita. An early prolific variety having a yellow fecula shaded with pale pink. Flavor excellent
Blanca. At least twelve forms are planted under this type name. Both skin and fecula are light-colored
Burra. The largest and perhaps the coarsest type; a white and a red form exist. They are quick growers. Roots weigh up to several kilos. Probably identical with *India.*
Candela. Large puple-skinned roots with whitish inside.
Capitaleña. Root with a dark brown or even blackish skin, globose, fine flavor. Prolific.
Carbonera. Similar to Rosita, but has fewer and larger roots.

Colorada. The common red-skinned forms with a yellowish fecula are all grown under this name.
Cuarentena. A rare form, said to mature roots in forty days.
Mameya. Several distinct forms are known under this type name. Their feculas are yellowish and usually sweeter than in most other types.
Morada. An excellent variety with beautiful streaks of purple in the fecula.
Melendres. One of the best sorts grown here The small, white roots cook quickly, and are granular and remarkably sweet.
Negra. One of the most striking plants in the whole realm of agronomy: the stems and leaves are of a rich dark maroon purple, becoming almost indigo black with age. The roots are, strange to state, unusually white, slender and of very poor quality. Plants at Vega Baja Model Farm succumbed twice to insect attacks. Very rare.
Rosita. Has rose-colored roots.
Yoya. A regular variety having white roots; leaves are strongly lobed, vines entirely green; prolific.

Other varieties possibly identical with some of the above are: Cangrejera, Gurabeña, Mayagüezana, Ranina.

BAY. See **Malagueta.**

BAY BEAN See **Mato de Playa.**

BAY Lavender. See **Nigua.**

BEAN. See **Habichuela.**

BEAN, Civet. See **Haba de Sieva.**

BEAN, Jack. See **Canavali.**

BEAN, Lima. See **Haba.**

BEAN, Red Jack. See **Canavali Colorado.**

BEAN, Wild Yam. See **Habilla.**

BEET. See **Remolacha.**

BEGGARWEED. See **Junquillo.**

BEJUCO DE CONCHITAS; *Clitoria ternatea* L.

An Old-World vine thoroughly naturalized here. Does not seem to be appreciated as a pasture forage here as it is in St. Croix, U. S. V. I. Three forms in evidence.

BEJUCO DE COSTA; *Ipomœa stolonifera* (Cyrill) Poir.

Common along the coasts of Porto Rico and neighboring islands, stem is sometimes partially buried in sand; 3–10 m. Leaves and vines commonly used as pig feed.

BEJUCO DE PUERCO; *Ipomœa rubra* (Vahl.) Millsp.

Very common in wet or moist soil in the northern districts of the Island; 1–3 m.; the young branches hairy. Leaves and vines used for pig feed.

BEJUCO DE PUERCO; *Ipomœa tiliacea* (Wild.) Choisy.

An extremely common vine in waste grounds everywhere; 2–5 m.; roots sometimes bearing small tubers. Leaves and stems gathered from waste grounds—never cultivated—and used for pig and rabbit feed. Indigenous and possibly the original ancestor of *I. Batatas* (L.) Lam.

BELL APPLE. See **Parcha.**

BENE. See **Ajonjoli.**

BERENJENA; **Eggplant**; *Solanum Melongena* L.

One of the commonest and most satisfactory of the "temperate" vegetables; marketed over a season of some 9 months. Both the place of origin and the wild form are quite unknown. The cultivated plant may easily be and often is grafted on a wild species, Berenjena Cimarrona (*S. torvum* Sw.), with good results; fruiting period may last a year. Three or four varieties are popular; the black-fruited seem hardier than the white ones.

BERROS; **Water-Cress**; *Sisymbrium Nasturtium-aquaticum* L.

Semi-cultivated, fairly common salad plant. Grows in shallow streams. Native of Europe and Asia. Sometimes in markets in large quantities.

BERZA; **Kale, Collards**; *Brassica oleracea* L. var. *acephala* DC.

This "temperate" vegetable succeeds fairly well here, but is severely attacked by insects Worthy of extra efforts. Several varieties. Excellent for "greens" and soups.

BERZA DE GANADO; **Cattle Kale**; **Thousand-headed Kale**; *Brassica oleracea* L. var. *ramosa* Alef.

This common European forage plant is unfortunately rare here; has succeeded at Vega Baja Farm and Trujillo Station. Injured by drought.

BINUKAO; *Garcinia binucao* Cy.

A medium-sized second-class fruit tree, 10–15 m., or more, introduced *via* United States Department of Agriculture from the Philippine Department of Agriculture. Fruiting at Mr. H. I. Sewall's place at Naguabo. Fruit shaped like a mandarin orange, yellowish green when ripe, 3–5 cm. or more in diameter, pulp almost too acid to use without sugar.

BIRIBA; *Rollinia* sp.

A splendid specimen of this excellent Brazilian first-class fruit tree is in evidence near Río Piedras, 5–10 m.

The fruit resembles the Corazón in shape but is larger, much more juicy and aromatic as to pulp, and somewhat like the Anón as to color and surface.

BIRIJI; *Eugenia monticola* (Sw.) DC.

A fairly common shrub or small tree, 6–10 m., in the waste lands of the Interior. Fruits roundish, black, about 5mm. in diameter.

BLACKBERRY. See **Zarzamora.**

BONAVIST BEAN. See **Chícharos.**

BREADFRUIT. See **Pana.**

BREADNUT. See **Nuez de Pan.**

BROCCOLI. See **Coliflor.**

BRUSSELS SPROUTS. See **Col de Bruselas.**

BUCARE; *Erythrina Pœppigiana* (Walp.) O. F. Cook.

A common coffee-shade and roadside tree, 15–25 m.; introduced from Peru. Leaves are a nutritious forage.

BUCARE; *Erythrina Berteroana* Urban.

A common Tropical American tree, 5–8 m. The leaves and small branches may be used as forage for rabbits and cattle. Leaves dried may be ground and used like Alfalfa meal. Frequently planted along roadsides.

BULALA, Pulasan; *Nephelium mutabile* Bl.

This excellent Oriental fruit tree has just been introduced at the Trujillo Plant Propagation Station; 10–15 m.; fruit reddish brown or greenish, somewhat resembling the Rambután, with a delicious sweet or sub-acid transparent pulp surrounding a large seed. This should rank with the Limón and the Rambután as much better fruits than the Quenepa.

BUNAG; *Garcinia Benthami* Pierre.

This interesting species from Cochin China and Philippines is in evidence (7 m.) in the collection of Garcinias belonging to Mr. Sewall at Naguabo. The fruit is similar to the Mangosteen but smaller, redder and more acid.

CABBAGE. See **Col.**

CACAO; Cacao; *Theobroma cacao* L.

A small tree introduced in 1636 from continental Tropical America, 4–9 m. Cultivated sparingly in the Maricao and Las Marías districts, and found in at least 3 of the 12 or more distinct forms; the Forastero occurring much more commonly (in both the red and yellow sub-forms). The Criollo is extremely rare and the Calabacillo is seldom seen. Most of the dried (mixed) seeds are bought by the chocolate factory in Mayagüez. A considerable quantity of the dried "beans" is used locally by the producers. In 1903 14 forms of cacao were brought in (as fruits) from Trinidad, B. W. I., to the U. S. Experiment Station in Mayagüez and planted out on the Station's grounds.

CACAO DE NICARAGUA; Nicaraguan Cacao; *Theobroma pentagona* Bernouili.

This was introduced about 1903 at the Federal Experiment Station at Mayagüez. Although a very delicate species it has succeeded fairly well here.

CACAO WARIBA; Patashte; *Theobroma bicolor* H. & B

An interesting Central America tree, 5–10 m. The large cacao-like seeds in the large (0.7–1 kilo) hard-shelled fruit are used in various confections. Introduced from Trinidad in 1903; growing vigorously from seeds at Trujillo Plant Propagation Station

CACTUS. See **Tuna.**

CACHIMAN; *Rollinia mucosa* (Jacq.) Baill.

Small forest tree, bearing roundish fruits 7 cm. or more in diameter; "pulp white, mucilaginous, sweet, edible", according to Britton & Wilson. Wild in western districts. Cultivation intended, experimentally. Closely related to the excellent Biribá (*R. deliciosa Safford*), of Brazil.

CAFE DE ABEOCUTA; *Coffea abeokuta* Cr.

This species was obtained from the island of St. Lucia in 1904 and tried first at La Carmelita Sub-station. It is still under test at the U. S. Experiment Station in Mayagüez. It resembles in foliage, fruit, and habit the typical *C. liberica.*

CAFE DE ARABIA. See **Café Común.**

CAFE CANEFORA; *Coffea canephora* Pre.

This interesting coffee was received from the French Government in 1908 by the U. S. Experiment Station. It is a late-bearing coffee and the bean is of medium size. It is closely related to *C. robusta.*

CAFÉ COMUN, Café de Arabia; Arabian Coffee; *Coffea arabica* L.

This species, which today furnishes some 90 per cent or more of the world's coffee, was introduced into Porto Rico from Haiti in 1736; the Haitian plants were probably brought from Martinique about 1735, the first plants reaching the latter island from Java about 1720. Practically no variation is in evidence here after nearly 200 years; however, a morphological "freak" has occurred near Barros, in which the seeds are reversed (back-to-back) in the fruit, and a multi-seeded form came to light through La Carmelita Sub-Station about 1909. As cultivated, 3–5 m.

The seed of the Porto Rican coffee ranks in commerce as one of the three to four best varieties; it is uniform in size, rather large, of a good "bold" appearance, varying from a pale grayish blue to a dark greenish blue. It is not very rich in caffein (probably about 1 per cent, as against 1.5 per cent for certain Central American and South American types) and is not so "rich in the cup" as some varieties, but it is an excellent "blender". It is more popular in Europe and Cuba than in the mainland.

The acreage at present is about 160,000. The average yield per acre is about 300 pounds of marketable "beans". The average export is around 15,000 tons.

The crop season is August to December. The shrub flowers (January to April) about five times, the berries ripening in six and one-half or seven months; all the plants in a district bloom at the same time. The "Caracolillo", or Peaberry, seeds are merely the seeds from 1- instead of 2-seed fruits borne at the tips of the branches; the percentage of these 1-seeded berries in Porto Rican coffee is 6 to 8 per cent. In size the common variety here weighs about 139 to 147 grams per 1,000 seeds, as against 242 grams for Liberian seeds and 78 for "Mocha".

The skin and pulp (which contains considerable sugar) removed at the plantation are allowed to decay in heaps and this material is usually (after several months) used as a manure; the parchment is used at the coffee mills, or "tahonas", for fuel; the "silver skin" membrane adhering to the seed, collected from the "tahona", has been succesfully used in several feeds (principally "Melca", a mixture of molasses and coffee middlings and "Caftor", a cattle feed made by mixing equal weights of the "dust" and grapefruit juice or pulp) and fertilizers made up at the By-products Plant in

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* "Coffee Varieties in Porto Rico", by T B McClelland, Horticulturist, U S Agricultural Experiment Station, Mayagüez, P R; Bulletin No 30; issued June, 1924

This Bulletin treats some 20 species and varieties of coffee in a semi-technical way

Mayagüez; it has also been used as a carrier for tobacco extract in making up various "nicotine" insecticides. Its analysis is: Protein, 10.67 per cent; fiber, 36 per cent; carbohydrates, 35.2 per cent; ether extract, 3.2 per cent.

Other introduced varieties of Arabian coffee in Porto Rico (in evidence at the U. S. Experiment Station and at some few points—whither distributed almost entirely by the Federal Station) are:

Bourbon, introduced from Salvador.
Pointed Bourbon, a long-seeded variety, discovered in Reunion, of distinct habit of growth as well as of seed.
San Ramón, a splendid dwarf type from Salvador, having a bearing season of six months (August to January).
Columnaris, a tall-growing form discovered in Java.
Erecta, a Java variety having ascending lateral branches.
Maragogipe, a Brazilian variety, coarse in growth, strong in flavor, and poor in yield, introduced about 1904.
Mocha, a small-seeded form from Java, which perhaps may be considered a distinct sub-species (*C. "mokka"*).
Murta, a dwarf, late-bearing form from Brazil.
Preanger, a mediocre variety from Java; introduced in 1904.
Menado, a mediocre variety from Celebes introduced in 1904.
Philippine, a mediocre variety from Philippines introduced in 1904.
Guadeloupe, a variety from Guadeloupe, F. W. I.
Surinam, a variety from Dutch Guiana, S. A.
Haitian, a variety from Haiti.
Alta Verapaz, a variety from Guatemala, introduced in 1904.
Harrar, a variety from Abyssinia, introduced in 1904.
Kona, a variety from Hawaii, introduced in 1904.

CAFE DE CONGO; *Coffea congensis* (Fro.) De Wild.

This species belongs to the Robusta group and hybrids of it with other species may become very popular in the future. One variety of this species, "Chalotii", has large leaves and is quite productive.

CAFE DEL CONGO; *Coffea Laurentii* De Wild.

This variety was received from the U. S. Department of Agriculture at the U. S. Experiment Station. It is commonly cultivated in the Congo Free State. One tree at the U. S. Experiment Station in Mayagüez has continued for years giving a very heavy crop; according to Mr. T. B. McClelland, Horticulturist of the said Station, the yield in one season was 19.4 liters and it has often produced half an almud.

CAFE DE DEWEVRE; *Coffea Dewevrei* De Wild.

An interesting species, indigenous in the African Congo, introduced by the U. S. Experiment Station in 1911. A late-fruiting species giving its principal crop in December, January and February. Smaller crops may be obtained in October and November, and also in March, April and May. In fruiting habit this species resembles the Liberian but has thinner pulp and more clustered fruits; the size of the fruits ranks as about third in the list of the varieties thus far tested at the U. S. Experiment Station. Budding has been successfully accomplished with this species.

CAFE DE DYBOWSKI; *Coffea Dybowskii* Pierre.

This species was introduced in 1905 through the U. S. Experiment Station at Mayagüez.

CAFE ESTENOFILA; **Bush Coffee**; *Coffea stenophylla* G. Don.

Though this excellent species was introduced at the U. S. Experiment Station some time ago it did not succeed well and was unfortunately ignored in the recent excellent coffee development work of that Station. In 1924–25 quantities of fresh seeds have been presented to this Department by the Botanic Gardens of Dominica and several thousand seedlings are now propagating at the Forestry Station, Experiment Station, and Trujillo Plant Propagation Station for immediate distribution to the Model Farms (San Sebastián and Villalba) and to coffee collaborators in the interior. It is claimed that this small-seeded coffee yields two or three times as much weight of product per given area as does the regular Arabian.

CAFE EXCELSA; **Excelsa Coffee**; *Coffea excelsa* Chev.

This species, according to Bulletin No. 30 of the U. S. Experiment Station, was discovered in 1905 my M. Chevalier in West Africa near Lake Tchad.

Received from the French Government at the U. S. Experiment Station in 1905. These trees have succeeded fairly well in the U. S. Experiment Station test plats and this species is today considered one of the most promising Coffees for futher experimental planting. Its fruiting season is perhaps the latest of all known Coffees, March and April being the two heaviest bearing months, with May and June not much less; this late-fruiting habit may have considerable advantage in some districts of the Island.

CAFE HIBRIDO; "*Coffea ugandæ*".

Seed of this hybrid cultigen was introduced by the U. S. Experiment Station in 1918 from the Java Experiment Station. It belongs to the Robusta type and appears to have a variable fruit,—both as to size, shape and color.

CAFE DE LIBERIA; Liberian Coffee; *Coffea liberica* Hiern.

The largest of the commercial coffees, introduced at La Carmelita Coffee Sub-station of the U. S. Experiment Station in 1904. A specimen of this species near Adjuntas is about 12 m. or rather more than the average height of the cultivated trees in the Republic of Liberia; occasionally specimens reach 16 m. This species is not cultivated as a crop in Porto Rico; it appears to fruit fairly well but the size of the berries is quite variable; the fruits are, on an average, about 65 per cent heavier than those of the common Porto Rican coffees. No hybrids appear to be under cultivation here at present, although at least one has been produced (with *C. arabica*).

CAFE QUILLOU; *Coffea quillou.*

This was imported *via* the Dutch East Indies from the French Congo into the U. S. Experiment Station in 1914. This variety of the Robusta type appears to be one of the most productive of the so-called "new" coffees. Its bearing season is from November to March, with January showing the heaviest crop.

CAFE ROBUSTA; *Coffea robusta* L.

This excellent coffee has been grown in Porto Rico since 1904 when it was introduced at La Carmelita Coffee Sub-station. Recently rather extensive plantings have been made at the U. S. Experiment Station at Mayagüez and considerable seed has been distributed. The season is decidedly late, the principal crop coming in January instead of September and October as with the common Coffee.

CAIMITILLO; Lechesillo; *Chrysophyllum bicolor* Poir.

An indigenous species from the north side of Porto Rico; 10–15 m.; fruit smooth, oblong or roundish, 2–3 cm. long, 1- or rarely 2-seeded.

CAIMITILLO, Teta de Burra; *Chrysophyllum oliviforme* L

An indigenous tree, common in all forests of the Island. 8–15 m. Fruit oval, 1–2 cm. long, purple or blackish, usually 1-seeded, the pulp extremely sweet, purplish

CAIMITILLO, Murta, Guasávara; *Mouriri domingensis* (Tuss.) Spach.

A tree 8–10 m. indigenous in many parts of Porto Rico and Vieques; fruit roundish, yellow, about 15 mm. in diameter.

CAIMITILLO VERDE; *Chrysophyllum argenteum* Jacq

A rather rare indigenous species from the old forests in the moister districts of the Island; 10–12 m. Fruits small, roundish or oblong, 8–14 mm.

CAIMITO; Star-Apple; *Chrysophyllum Cainito* L.

Probably indigenous first-class fruit tree, common throughout Tropical America; 10–20 m. Two forms of the fruit are found here, the green and purple. Practically no difference exists in the flavor, size or other characters of the fruit,—the purple or nearly black color, although it extends into the outer pulp of the fruit does not give a flavor different from that of the green form. Very seldom planted and never on a large scale; the fruits, however, bring a fair price on the market and are popular everywhere.

CAIMITO DE PERRO. See **Caimitillo.**

CAJUIL. See **Pajuil.**

CALABAZAS; Squashes; *Pepo (Cucurbita) Pepo* L.,
Pepo (Cucurbita) moschata (Duch.) Britton.
Pepo (Cucurbita) maxima (Duch.) Britton.

An unknown number species, sub-species, varieties, and hybrids of same are grown here widely but not to any great extent.

Certain varieties, presumably of the true "Field Pumpkin" type, are to be found in the markets throughout the year. In the drier regions of the Island many tons of these old garden fruits are produced each season and they hold a rather important place in the diet of the urban as well as the country people. Even several varieties of the "Summer Squashes" are occasionally found in the large groceries of San Juan. On account of the readiness with which most of the Cucurbits hybridize it is practically impossible to be certain that any varieties of these fruits found here are absolutely pure. No special care is taken to prevent cross breeding; the plants are largely left to find their own supports (trees, fences, etc.).

From the investigations made in Eastern and Central Peru in 1915 by Dr. O. F. Cook, of the U. S. Department of Agriculture. (an eminent authority on plant origins), it appears certain that the aborigines in the Central Andean region had domesticated at least three distinct types of squashes: one with hairy seeds which may be extinct at present; one with small white seeds; one with large black seeds. Very likely some of these primitive squash-like plants were the ancestors of our present-day varieties, and they were probably introduced into Porto Rico *via* one or both of the routes suggested in the preface.

CALAMBREÑA; *Coccolobis venosa* L.

An indigenous tree of the waste lands in both dry and moist districts of Porto Rico and neighboring islands; 8–12 m. Fruits white when ripe, 3-angled, about 6 mm. long; the pulp white, quite edible, very juicy.

CALAMONDIN; *Citrus mitis* Blanco.

This very interesting Philippine fruit was introduced some time ago (about 1911), but has not been extensively planted. Some 50 trees, 3–8 m., are in evidence in the Guanajibo district of Mayagüez; the crop of "scarlet limes" is regular and heavy, and the beautiful fruits hang on the branches for months after ripening. This fruit is unquestionably of most value as an "ade" fruit (for drinks, sherbets, etc.); its loose peel is an advantage therefor.

It has been used as a parent in the seven following hybrids:

Citraldin, (with *Poncirus trifoliata*).
Sopomaldin, (with *C. grandis*).
Calarin, (with *C. nobilis deliciosa*).
Calashu, (with *C. nobilis unshiu*).
Faustrimedin, (with *Microcitus australasica*).
Bigaraldin, (with *C. aurantium*).
Citragedin, (with the *citrange*).

CALLALOU. See **Yautía.**

CAMANCHILE; *Pithecellobium dulce* (Roxb.) Benth.

A Central American shrub or small tree, 5–10 m. Has been planted near the Director's residence at the Mayagüez Experiment Station and elsewhere. Apparently variable; one Mexican variety has pods 20–30 cm. long. The sweet, whitish, fleshy pulp is very wholesome.

CAMANDULAS; **Job's Tears**; *Coix Lachryma Jobi* L.

Scarcely cultivated, but common. The luxuriant foliage is of some feeding value, but the grain envelopes of the old ordinary form are too hard to be safely used as feed (even when ground) for animals. The only forms worthy of cultivation are the newly introduced Adlays from the Philippine Islands. Native of Tropical Asia.

CAMOMILA; **Chamomile**; *Anthemis nobilis* L.

A first-class seasoning herb with a very pleasant aroma; native to Europe. Introduced from France in 1924. Testing at the Plant Propagation Station.

CANAVALI; **Sword Bean, Jack Bean**; *Canavali ensiformis* (L.) DC.

An old East Indian Bean, 1–2 m., cultivated in fruit orchards, of little importance as a food plant. The large white seeds may be eaten with little danger provided they are soaked several hours in warm water and then "hulled" by rubbing off the loosened coarse skins; the "first water" in which they are cooked should be thrown away.

CANAVALI COLORADO; Red Jack Bean, Horse Bean; *Canavali gladiata*, DC.

This rare plant is growing luxuriantly at the Plant Propagation Station. It may be of value as a forage and cover crop, but the very succulent foliage might require (partial, at least) drying before feeding to cattle. The crimson seed is larger than the white Canavali, and very different from the wild mato colorado (*C. rusiosperma* Urban) of the forests in the western end of the Island; plant much larger, 3–10 m.

CANDLE-NUT. See **Nuez de la India.**

CANDLE-TREE. See **Palo de Vela.**

CANE. See **Caña.**

CANELA; Cinnamon; *Cinnamomum zeylanicum* Nees.

A fine specimen of this famous species is in evidence in Mayagüez; about 6 m.; probably introduced about 1895. Native of South Asia.

CANELA DE CHINA; Cinnamon; *Cinnamomum Cassia* Blume.

A rare tree occurring in various scattered localities, never actually cultivated; introduced in 1903, a tree in the Federal Experiment Station orchard had reached a height of 3.7 m. in 1905. The bark appears to be utilizable but has never been put on the market here. Native of China.

CANELA DE COSTA, Barbasco; Winter Bark, Pepper Cinnamon; *Canella Winterana* (L.) Gaertn.

This indigenous shrub or small tree, 5–15 m., occurs in many localities, especially along the coastal area of Porto Rico and the neighboring islands. The highly aromatic and fragrant bark yields not only an excellent condiment but also a medicinal tonic.

CANISTEL, Ti-es; Egg-fruit; *Lucuma nervosa* A. DC.

A very interesting Cuban fruit introduced in 1903 at the U. S. Experiment Station; 5–10 m. This tree fruited in 1908 at the said Station but has never been distributed about the Island as it should have been. The fruit is one of the richest of all the sapotes; the sweet dry yellow pulp may be eaten raw, or made into pies or jam. Testing at the Trujillo Plant Propagation Station.

CANNA, Edible. See **Maraca.**

CAÑA, Caña de Azúcar; Cane, Sugar Cane; *Saccharum officinarum* L.

The precise habitat wherein this luxuriant grass was first reclaimed as a tame crop may never be known; in fact, there may have been several points of origin: A. de Candolle appears to consider its primitive range (as a domesticated plant) between Bengal in India and Cochin-China; but, if the Uba cane be regarded as of this species, South China was probably the mother country of one or more types of cane; and recent explorations have revealed the fact that in central New Guinea there are today large districts wherein savage tribes plant cane (probably of several varieties) from *the seed*, like sorghum or maize,—which might well indicate that there it has not lost by any means so much of its pristine seed vigor as elsewhere.

Certain it is, however, that Don Enrique, Infante de Portugal, took it about 1420 from Cyprus or Sicily to the Madeira Islands; the Arabs had brought the "honey-bearing reed" presumably from South India to Egypt, then to Sicily and Spain, rather early in the Middle Ages. From Madeira it was taken to the Canary Islands in 1503 and thence, a few years later (probably about 1505–1506) to Hispaniola. According to one account Columbus took it to Hispaniola in 1493. It was probably one of the first very important introductions (from the Island of Haiti) into the world's first agricultural Experiment Station on the Toa River, near Toa Baja; evidence indicates that it was established there *before 1520.*

The variety grown in Porto Rico, from say, 1515 to about 1800 was the soft-rinded, weak growing *Criolla*. During the 19th century scores of varieties were introduced here from the other West Indies Islands and from Brazil, but not till about 1905 did the multitude of seedling varieties begin to appear in cultivation

Mr. Arthur H. Rosenfeld, Special Cane Technologist of the Insular Experiment Station at Río Piedras, Porto Rico, has kindly prepared the following summary in regard to present-day cane varieties.

Some 500 distinct varieties of sugar cane have been tried out at the Insular Experiment Station and the Federal Experiment Station, as well as on the plantations, around one-fifth of that number being cultivated to some extent on the plantations today. The following, however, represent the most generally cultivated and promising varieties on the Island today, in the order of their actual importance and distribution:[1]

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[1] For full descriptions and discussions of most of these varieties, see. *Rosenfeld, Arthur H*—"The Java P O J Canes in Tucumán and Porto Rico" and "The BH 10(12)

Barbados Hybrid 10(12) and *St. Croix 12/4*. By a remarkable coincidence, since these are easily the two most promising varieties on the Island, both of these canes were produced by the Hon. Jno. R. Bovell, Director of Agriculture in Barbados, from the same parent, *B 6835*, the *S. C. 12/4* having been taken by Mr. Bovell to St. Croix when on a visit to that Island when it was yet but a tiny unnamed seedling cane and when nothing, naturally, was known of its characteristics. Both are canes of good tonnage and high sugar qualities and they are rapidly replacing the old standard *Cristalina* and other varieties in the better soils of the Island of Porto Rico. For example, Mercedita de Ponce at present has practically 100 per cent of her entire acreage in these two canes, while around 50 per cent of the entire South Coast cane area is now devoted to these canes. The indications are that this percentage will rapidly increase in the better cane areas all over the Island in the coming few years.

Cristalina. Known in Hawaii as *Rose Bamboo* and in the British West Indies as *White Transparent*. "The grand old cane" of the sugar industry of the world, having probably produced more sugar than any other variety during the generations that it has been cultivated. Is one of the *Cheribón* canes which for years formed the basis of the cane plantations of well-known sugar countries such as Java and Cuba, in the latter of which it still constitutes approximately 99 per cent of all the cane cultivated. On the South Coast of Porto Rico this was for years almost the only cane planted, with the exception of the now almost extinct *Otaheite*, but, as indicated above in the discussion of the *B. H. 10(12)* and *S. C. 12/4* varieties, it is now rapidly being replaced by them.

Rayada. Also known as *Louisiana Ribbon* or *Striped Cheribón*. Like its sister cane, the *Louisiana Purple*, it is nothing more nor less than a color mutant of *Cristalina* and until recently was as important a factor in North, East and West Coast production in Porto Rico as was *Cristalina* on the South Coast. Like its sister, it is rapidly being replaced by the *B. H. 10(12)* and *S. C. 12/4* varieties and its practical disappearance from the Island in a few more years can confidently be predicted.

Demerara 433. Known all over the Island as *Ceniza* or *Fajardo* cane, this variety represents an interesting case of a variety of rather undesirable characteristics in general developing special adaptation for a particular zone, which in this case is the Northeast corner of Porto Rico, where the

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and SC 12/4 Canes", in Jour. of P R Dept. of Agr, VIII and IX, Nos 3 and *López Domínguez, F*—"The Sugar Yield of the Uba Cane in Porto Rico", in Bull 28 of Insular Experiment Station of Porto Rico.

Experiment Station of the Fajardo Central, through the competent efforts of Messrs. McConnie and Veve, has brought up its former production to around 100 per cent increase. Fajardo has of late developed some seedlings of this cane which bid fair to gradually replace the parent, notably *F. C. 140, 214* and *306,* their order of importance at present being in the reverse of their enumeration here.

Uba. One of the groups of North Indian canes which Dr. C. A. Barber considers as belonging to the *Pansahi* group. Generally classified as a distinct species from the "noble" canes usually grown, which come under the *Saccharum officinarum* species, while Brandes considers that the *Uba* group belongs to the *sinensis* lot.[1] The variety generally cultivated in Porto Rico is what is known in Argentina and Brazil as *Kavangire,* this name probably being due to a mixing of varietal labels, but at any rate our commonly cultivated Chinese cane seems distinct from the genuine *Uba de Natal* in behavior if not in readily discernible botanical characteristics. This cane was sent in 1917 from the Tucumán Sugar Experiment Station in Argentina to Mr. D. W. May, Director of the Federal Experiment Station in Mayagüez, P. R., and, after its complete immunity to Mosaic Disease had been proven several years later by Mr. F. S. Earle, then Cane Technologist of the Porto Rican Insular Experiment Station, a large shipment was brought up from the Tucumán Station and it has since been widely cultivated on the West Coast of Porto Rico, where the ravages of Mosaic Disease were particularly severe and rogueing most impracticable. It is a rustic type of cane, with a very thin stalk and closely adhering leaf sheath which makes preparation for the mill difficult and expensive, but on poor, hilly lands, where other types of cane give almost nothing, it will produce quite satisfactory yields at a ridiculously low cost of cultivation—particularly as ratoons. Its sugar content is variable, however, and likely to be low in cropping seasons of high precipitation, and it is not venturesome to predict that in a few years it will commence to be replaced quite quickly by some of the *P. O. J.* (*Proefstation Oost Java*) crosses produced by Kobus in Java, one of the most promising of which is mentioned below.

P. O. J. 36. This is a controlled cross of *Chunnee,* of the North Indian type, with *Striped Preanger* of Java. As both parents are susceptible to Mosaic Disease—Kobus was breeding for resistance to Sereh—this variety, like others of the group, is not immune, but becomes infected with great facility. The deleterious effect of Mosaic, however, is not great on account of the tolerance of *Chunnee,* which appears to have been transmitted in high degree to this seedling. It is a comparatively slender variety, but a most prolific stooler and ratooner and, while under ordinary favorable conditions this cane will probably not outyield the "noble" canes, under conditions approaching disease saturation, their striking superiority is nothing less than phenomenal. Considerable of this variety is now being cultivated on the West Coast, in the vicinity of Añasco and Rincón, and Central "Los Caños", near Arecibo, under the very progressive administration of Mr. Antonio Fraticelli, has a large area of it which has been giving most excellent results. The Insular Experiment Station is now multiplying Mosaic-free seed of this variety for extensive distribution in districts where *Kavangire* is being largely grown, the results from which were rather unsatisfactory in the past crop. Beginning with disease-free seed, it should be entirely practicable to rogue plantations of these resistant canes and maintain them free of Mosaic Disease, enabling this section to grow a better type cane than the *Kavangire* without recommending cultivation of cane 100 per cent infected with Mosaic. This cane gives quite good sugar yields, will grow on lands as poor as that which will still produce the Japanese type and is as easy to strip as *Cristalina* or *B. H. 10(12)*.

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[1] Breeding of Disease-Resisting Sugar Plants for America. Ref. Book of Sugar Ind of the World La Planter; July, 1925

Demerara 1135. This is a variety which, while of no promise whatsoever in the place of its production, has given most promising results under unfavorable conditions in Tucumán, Queensland and Hawaii. It is somewhat similar in size and characteristics to the *P. O. J. 36*, susceptible to attack of but to some degree resistant to the effects of Mosaic Disease, although not to such a marked extent as the *P. O. J. 36*, drought-resistant, easy to strip for mill and a remarkable germinater, stooler and ratooner. The Insular Experiment Station at Río Piedras is pushing this variety as advisable for the unfavorable conditions of the North and West Coast and for the very dry Island of Vieques. Several centrals will have substantial quantities of this variety for cropping in 1926–27, when its adaptation to Porto Rican conditions can be more adequately determined.

Two of the new Barbados seedlings are giving such excellent results on a small scale that it is practically certain that they will replace some of the above-mentioned seedlings in the near future; they are B. 6032 and B. 11569.

At the U. S. Experiment Station, the Río Piedras Experiment Station, the Fajardo Sugar Co., Guánica Central, and elsewhere in the Island thousands of seedlings have been raised and many of these are now under test.

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* "The Java P O. J Canes in Tucumán and Porto Rico", by A H Rosenfeld, "Journal of the Department of Agriculture and Labor of Porto Rico", Vol. VIII, No 3, July 1934.

Since the early part of the 19th century, cane has surpassed coffee as the principal crop. About 1900 a great impetus was given to cane culture here through the opening of the mainland markets and the extension of the area under cultivation has not yet stopped.

The following statistics are illuminant:

The present acreage under cultivation varies from 225,000 to 280,000.

In 1896–7 the crop amounted to only 58,000 tons.

About 1900 the production was less than 100,000 tons.

In 1917 the crop was 448,000 tons.

The 1924–25 crop is estimated at around 650,000 tons,—or about 30 per cent greater than ever before.

There are now 39 centrals in operation.

The average export value of the sugar crop for the past five years has been over $61,000,000.

CARAMBOLO; *Averrhoa Carambola* L.

Rare second-class introduced (Oriental) fruit tree, 3–6 m.; cultivated in Loíza and Carolina districts, from whence fruits are sold during season (July to September) in San Juan. The very acid fruits are used for jellies and preserves; a very rare, less acid, variety eaten fresh.

CARROT. See **Zanahoria.**

CASABE. See **Yuca.**

CASHEW-NUT. See **Pajuil.**

CASSABANANA. See **Pepino Angolo.**

CASSAVA. See **Yuca.**

CASTAÑA DE AUSTRALIA; **Moreton Bay Chestnut**; *Castanospermum australe* A. Cunn.

This species was recently introduced by the U. S. Experiment Station but will probably not fruit for some time since the tree is very large, at least in its natural habitat. The nuts are among the very best.

CATNIP. See **Hierba Gatera.**

CAT-TAIL. See **Enea.**

CAULIFLOWER. See **Coliflor.**

CAYUR. See **Corazón Cimarrón.**

CEBADA; Barley; *Hordeum vulgare* L.

This polymorphous old cultigen, or cultivated hybrid, of very obscure origin was introduced at the Toa Grange about 1515 and was repeatedly planted here; but it has disappeared except as an occasional "curiosity exhibit".

The spent grain from the brewery in Santurce has been successfully used as a local dairy feed.

CEBOLLA; Onion; *Allium Cepa* L.

Commonly cultivated, especially in the northwestern portion of the Island; no large fields, but the total acreage may run into hundreds. Yield usually fair, but considerable trouble is experienced in curing the bulbs to prevent decay between field and counter. Several varieties are common, the white, so-called "Bermuda" or "Canarias" type, usually being preferred to the red or yellow types. Native to Western Asia Both the rare multiplier, or potato, onion (A. *Cepa* var *solaninum* Alef.) and the top onion (*A. C. viviparum* Metz) are also being tested by the Department.

CEBOLLA DE GALES; Welsh Onion; *Allium fistulosum* L.

This Siberian chive-like vegetable is being tested at the Trujillo Plant Propagation Station.

CEBOLLIN; Chive; *Allium Schœnoprasum* L.

An obscure but not very rare vegetable, successfully cultivated in the higher and well drained districts; commonly marketed in small quantities; used in flavoring soups and stews—both the long (5–10 cm.) slender bulbous bases and the savory leaves. Native in Europe and Asia.

CELERIAC. See **Apio-Nabo.**

CELERY. See **Apio.**

CERAFOLIO; Chervil; *Cerefolium Cerefolium* (L.) Britton.

A rather rare old seasoning herb from West Asia and S. E. Europe. Merits wider cultivation here.

CERAFOLIO BULBOSO, Perifollo de Bulbo; Tuberous-rooted Chervil; *Chæro phyllum bulbosum* L.

This old European vegetable is being tested at the Trujillo Plant Propagation Station; it will probably succeed in the higher elevations.

CEREUS. See **Pitajaya.**

CEREZA COLORADA; West Indian Cherry; *Malpighia punicifolia* L.

A fairly common second-class fruit tree, 4–6 m.; probably indigenous. Apparently slightly variable but in no types do the fruits exceed 2 cm. in diameter. The very acid, red fruits are sometimes eaten fresh but usually made into a sauce, jam or preserve with plenty of sugar.

CEREZA ESPAÑOLA; Spanish Cherry; *Mimusops Elengi* L.

A recently introduced East Indian tree, 8–10 m. or more; fruit egg-shaped, yellow, 2 cm. long, 1-seeded, with a dry sweet pulp.

CEREZA DE SURINAM; Surinam Cherry; *Eugenia uniflora* L.

Introduced through the U. S. Experiment Station at Mayagüez, in 1903. Still very rare. The red cherry-like fruits should be a valuable addition to our pomology.

CICELY. See **Mirra.**

CIDRA; Citron; *Citrus medica* L.

Introduced (as seeds) repeatedly from Europe (and probably America); the Adjuntas and Mayagüez district plants are descendant from Corsican *seeds* brought in by persons who had confidence in the future of the export industry here. A few *grafted* plants were sent hither (by the U. S. Department of Agriculture) from the genuine Corsican trees, and it is believed that a few sprouts are still in evidence.

Three or four small orchards, one coming into full bearing, have recently been set out near Adjuntas; a gross income at the rate of over $1,000 per acre was reported last season from one of these groves. All trees are grown from short stake cuttings; but at the Trujillo Plant Propagation Station experiments are being made in budding onto Sour Orange and Grapefruit stocks and in one plantation near San Juan excellent results are showing from using strong old Grapefruit stocks; fruit is expected within 2 years by this method. At present the export price of fresh fruits (packed in barrels) is considered good, and this should increase somewhat, considering the fact (1) that consumption in the Middle States will probably increase, (2) that the cost of importing fruit in brine from the Mediterranean countries is high and conditions precarious, (3) that neither California nor Florida can, with commercial safety, expect to produce large and "steady" crops of this very sensitive (to frosts, etc.) fruit, and (4) that the current retail price for candied fruit (largely sugar) leaves a very wide margin for profit.

Test plats of Citron varieties are being established on the Model

Farms, and from these and the Plant Propagation Station propagating material will soon be distributed to planters who are being encouraged to grow at least a few of these exceedingly promising trees.

Dulces and confections have long been made from the common seedling fruits here (without brining); experimental work has been done in "brining" and "crystalizing" citron at the Mayagüez By-Products Plant, results indicating that the local humidity and the hygroscopic tendency of the sugared product militate against the establishment of the peel industry here. Cithon peel dries well but slowly in the said Plant's special dehydrator, and quite possibly this method may be used as an important factor in cheaply putting the raw material on the mainland market.

Three or four fairly distinct races, based on fruit characters, are already recognized; one, the "Boba" is large but lacks flavor.

The principal variety for export has been named *Preferida;* this is a very large oblong fruit with a fairly smooth surface; it appears to have two distinct habits; one called the *Erecta* grows fairly erect whereas the ordinary plant has the bad habit of allowing its branches (unless propped) to fall onto the ground, especially if carrying any fruit. Another variety known as the *Rugosa* is a medium-sized fruit of first quality but the rind is considerably wrinkled and the shape may be somewhat irregular. Still another form which has made its appearance in the Adjuntas plantations is called the *Híbrida;* it would appear that this is a cross with the Limón de Cabro as indicated by its inferior size, shape, and flavor and by its more juicy and acid pulp; this fruit is being studied.

Two trees of distinct habit and fruit on a plantation west of Adjuntas seem to be hybrids between the citron and some kind of "Lemon".

CIDRA DULCE; *Citrus sp.*

One or two trees, near Maricao and one near Añasco are known of this fruit. 'Foliage resembling that of Cidra but *spineless* or nearly so; fruit with thin peel, rich sweet "orange-like" pulp and some Grapefruit characters. Two trees are reported from Santo Domingo. Probably a valuable new fruit, at least for local use. Propagating at Trujillo Plant Propagation Station.

CILANTRO; **Coriander**; *Coriandrum sativum* L.

This European culinary herb ranks with Anise here. For dulces and pastry the seeds are excellent.

CINNAMON. See **Canela.**

CINNAMON, Wild. See **Malagueta.**

CIRUELA AMARILLA. See **Jobillo.**

CIRUELA; Spanish Plum, Red Mombin; *Spondias purpurea* L.

Second-class fruit tree, 4–8 m.; semi-cultivated throughout the Island, usually in fence-rows (where it grows from stake cuttings).

CIRUELA AMARILLA. See **Jobillo.**

CIRUELA DE LA CHINA; Chinese Plum; *Flacourtia cataphracta* Roxb.

This oriental species is sometimes cultivated for its round fruit which is about 1.5 cm. in diameter. The tree is smaller and more spiny than the sister species *F. Ramontchi.*

CIRUELA DE GUAYANA; Guiana Plum; *Drypetes lateriflora* (Sw.) Krug & Urban

A small tree native to the hills near Bayamón, 5–15 m. Fruit reddish, 6–11 mm. in diameter, dark brownish, hairy.

CIRUELA DE MADAGASCAR; Madagascar Plum, Governor's Plum; *Flacourtia Ramontchi* L'Her.

This Madagascan fruit shrub is occasionally grown here; 5–10 m or higher Fruit round, black,, about 12 mm. in diameter.

CIRUELA DE MALAYA; *Gmelina arborea* Roxb.

A rare Malayan second-class fruit tree presented by the Dominica Botanic Gardens, and distributing from the Trujillo Plant Propagat'on Station; 5–15 m. Fruit plum-like, very juicy

CIRUELA DEL MONTE; Mountain Plum; *Rheedia edulis* Planch & Triana.

This small-growing fruit tree is related to the Mangosteen; introduced by the U. S. Experiment Station at Mayagüez in 1903.

CIRUELA DE SANTO DOMINGO, Ciruelas; Santo Domingo Cherry; *Anamomis umbellifera* (H. B. K.) Britton.

A second-class fruit tree, native of Hispaniola. Fruit 1–1.5 cm. in diameter. Cultivated here.

CITRON. See **Cidra.**

CLAVO DE ESPECIA; Clove; *Caryophyllus aromaticus* L.

An extremely rare Oriental tree; does not succeed here. Several specimens have been introduced; one at Trujillo Plant Propagation Station now.

CLOVE. See **Clavo de Especia.**

CLOVER. See **Trébol.**

COCO, Cocotero; Coconut; *Cocos nucifera* L.

Although practically all closely related palms are indigenous in Tropical America, and while evidence points to Colombia as the locus where it *should have originated,* the 25 to 40 varieties of Coconut* have been grown since prehistoric times in Southern Asia, the East Indies, and Polynesia; and whether it came around the Cape of Good Hope with the early Portuguese navigators or was carried along the north coast of Africa into the East Atlantic archipelagoes by the Phœnicians or their successors, the fact seems quite and remarkably clear that neither Porto Rico nor any other part of Tropical America visited by the Spanish discoverers around 1500 had ever known the species as a food plant. (If ever found in the wild state it will probably be in some of the recesses of the Panaman or Colombian [Darien] wildernesses).

There is little doubt that Father Diego Lorenzo brought the first nuts from Cape Verde to Porto Rico sometime before 1525; presumably he had a considerable number of sprouting nuts and therefore both the Green and the Yellow forms of the species (which comprise at least 95 per cent of the 400,000,000 to 500,000,000 trees under some sort of cultivation in the world today) were undoubtedly introduced then. The few and very rare following varieties have been brought hither from time to time by unknown parties from unknown sources:

Golden; a beautiful nut, considerably below medium size, the surface of the roundish pericarp showing at all times a peculiar bronze yellow or golden brown color; the tree is rather small, 5–10 m.

Macapunó, the famous "solid-meat" variety from the Philippine Islands is said to have become established here long ago but the author has not seen a specimen; in this connection it should be remembered that not all the nuts on the Philippine tree have the "water cavity" filled with the "meat", the few (?) quasi-normal nuts being the means whereby the "freak" variety is propagated.

Chocó, this very large, thick-husked nut from the south coast of East Panamá has probably been established here.

San Blas, this famous variety from the north side of East Panamá (and the 365 islands of the San Blas chain) is or soon should be here; the rather elongate husk is thin and the shell is more easily removed from the "meat" than that of any other variety

It appears that none of the six or seven distinct varieties of dwarf coconuts have yet been introduced here; they should all be tested out in the shallow soils. The Ginaring, or Ivory Husk, and the Edible Husk varieties are to be introduced as soon as opportunity offers.

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* "The Philippine Coconut Industry", by O W Barrett, Bull 25, Bur of Agr, Govt of Philippine Ids, 1912

The Green and Yellow ordinary varieties reach, in good situations, 25 to 30 m., being at this height presumably over 75 years old.

Only a few tons per annum of copra are in evidence—made mostly in hot-air driers in Loíza and Humacao Playa; the steam-pipe hot-air dryers in evidence at the By-Products Plant in Mayagüez were devised in 1912 by the author to provide a cheap simple means for reducing the moisture content to the point (around 9 per cent) where moulds do not attack the copra (with the certain and deplorable loss of oil). Instead of making into copra here the sprouted, broken, rotting (from "eye" injury) and very small nuts are usually fed to pigs and poultry.

The annual export crop ranges from 20 to 25 million nuts; of these probably about 25 per cent are sold as culls at about half price. Neither wine nor sugar has ever been produced here from the (immature peduncle) sap. Probably not over 1,000 immature nuts are harvested daily for the "water" which is a popular beverage in the towns.

Both at Mayagüez and Humacao Playa coir factories produced a few thousand tons of fiber about 1914–15.

One of the closest wild relatives of the Coconut is the very interesting palm, *Calyptrogyne occidentalis* (Sw.) Maza, which is found about San Sebastián; since it appears that less than 500 specimens of this tree exist it must be considered (like some of the nearly extinct species of the Seychelles Islands) one of the rarest palms in the world: (established at the Model Farm near San Sebastián).

Comparatively little increase in coconut cultivation has occurred here since 1900; the acreage is supposed to be around 10,000.

COCOA-PLUM. See **Icaco.**

COCONUT. See **Coco.**

COFFEE. See **Café.**

COFFEE-SENNA. See **Hedionda.**

COITRE.

Six species of three genera of very similar plants are included under this common name here as follows:

Campelia Zanonia (L.) H. B. K.
Tradescantia geniculata Jacq.
Tradescantia elongata G. F. W. Meyer.
Commelina longicaulis Jacq.
Commelina elegans H. B. K.
Athyrocarpus persicariæfolius (D C.) Hems.

The very watery herbage of these plants is frequently harvested from waste ground, roadside banks and even cultivated fields and fed to pigs, rabbits and poultry partly as a roughage and partly for the popular belief that the cool sap (*sic*) is beneficial to the animals. Although never cultivated, in some districts these weeds are of considerable importance to the small farmer.

COL; Cabbage; *Brassica oleracea* L. var. *capitata* L.

One of the commonest and most appreciated "temperate" vegetables; succeeds better perhaps in the hilly moist regions, but Vega Baja produces excellent specimens in wholesale quantities. Many varieties of the three or four types are grown. Frequently badly attacked by a Tineid moth. Of West European origin. Imported from the mainland in enormous quantities in the August-October season.

COL DE BRUSELAS; Brussels Sprouts; *Brassica oleracea* L. var. *gemmifera* DC.

A very difficult vegetable to produce at sea-level in the Tropics, but can be grown at 1,000 m. Not popular.

COLA; Kola; *Cola vera* K. Schum.

This African tree is being distributed from Trujillo Plant Propagation Station; the seedlings seem to start off well. In Liberia, the Canal Zone and Dominica, the average tree at full maturity is hardly more than 5–8 m., although specimens probably attain a height of 10 m. or more. The pulp is edible, but the seed itself, containing two or three times as much caffein as coffee, is of great value as a stimulant and will eventually, it is believed, become a very popular beverage for the whole world.

COLIFLOR; Cauliflower and Broccoli; *Brassica oleracea* L. var. *botrytis* L.

Neither form of this vegetable succeeds well here. Popular.

COLINABO; Kohlrabi; *Brassica caulorapa* Pasq.

Occasionally cultivated, second-class vegetable. If grown rapidly in a cool moist soil the "stem tuber" is tender and usually devoid of bitterness.

COLLARDS. See **Berza.**

CONDOL; Chinese, Preserving Melon; *Benincasa hispida* Cogn.

This Oriental cucurbit has never succeeded here. The excellent flavor of the preserved rind is a good reason for further tests. Seeds brought in from Caracas, Venezuela, have not succeeded at Trujillo.

CONGO PEA. See Gandul.

CORAZON; Custard Apple; *Annona reticulata* L.

A third-class fruit tree, 4–8 m.; semi-cultivated in all and common in western districts, preferring well-drained soils. Fruits commoner during dry season. Variable from nearly inedible forms 7 cm. to delicious forms 15–20 cm. in diameter; the better sorts have pinkish or rosy pulp and a slightly acid, instead of sweetish, taste. Superior varieties have been introduced from Dominica and the American Virgin Islands. Fairly common in markets. Superior sorts probably exportable. Believed to be indigenous.

CORAZON CIMARRON, CAYUR; Pond Apple, Monkey Apple; *Annona glabra* L.

Inferior fruit tree, 3–10 m.; swamps and wet lands, never cultivated. Pulp insipid or slightly aromatic, resembling that of an inferior Corazón.

CORIANDER. See **Cilantro.**

CORN, INDIAN. See **Maiz.**

COROZO. See **Palma de Corozo.**

COTTON. See **Algodón.**

COWPEA. See **Frijol.**

COWPEA, PHILIPPINE. See **Silani.**

COYO, Aguacate de Guatemala; Guatemalan Avocado; *Persea Schiedeana* Nees.

This rare Guatemalan species is, of course, quite similar to the Avocado, but it can readily be distinguished by its pubescent branchlets and leaves and by the brownish white to pale brown pulp which *contains a milky juice* and has a *coconut-like flavor.*

This excellent fruit was introduced at the Río Piedras Experiment Station about two years ago; thus far it has not succeeded well. It may prove superior to the Avocado as an export and market fruit.

There are in Guatemala several varieties, the fruits of which vary from green to bronze brown, and may be either long- or short-necked; the skin is thicker than the regular West Indian sort but is not brittle or woody like the true Guatemalan Avocado.

CRESON; Garden Cress; *Lepidium sativum* L.

This rare West Asiatic vegetable is sometimes grown here; being tested at the Trujillo Plant Propagation Station.

CRESS, GARDEN. See **Creson.**

CRESTA DE GALLO BLANCO; *Teramnus uncinatus* (L.) Sw.

A slender vine, 0.5–1 m. or more long, indigenous to the Island, and Tropical America in general.

Used as a forage plant in St. Thomas, whence seeds (presented by Mr. A. Holst, the Danish Consul) were received in January, 1925, for trial at the Trujillo Plant Propagation Station. In this respect it resembles the Bejuco de Conchitas (*Clitoria ternatea* L.) and the high percentage of proteids in the fodder is undoubtedly about the same in both plants.

CUCUMBER. See **Pepino.**

CULANTRO DEL MONTE; *Eryngium fœtidum* L.

A very common seasoning herb occurring in fields and roadsides, 0.5 to 1 m. The leaves, preferably used fresh, give a flavor much relished by many to stews, soups and even pastries.

CULCAS; Egyptian Taro; *Caladium Colocasia* (L.) W. F. Wight.

Recently introduced from the U. S. Department of Agriculture and now growing at the Trujillo Plant Propagation Station. This relative of the common Malanga and Dasheen is one of the common crops of Egypt though it was probably brought there from the Orient in prehistoric times.

CUNDEAMOR; Balsam Apple; *Momordica Balsamina* L.

The young fruits of this and of the much rarer species ***M.*** *Charantia* L. are occasionally boiled and eaten with meats and rice; ripe fruits eaten by children. The leaves are reputed to have medicinal properties.

CURUBA. See **Parcha.**

CUTITIRIBA; *Lucuma macrocarpa* Huber.

A very rare recently introduced (from Brazil) fruit tree at the U. S. Experiment Station. Like most of the Lucumas the fruit is large and has a rich edible pulp.

CUSTARD APPLE. See **Corazón.**

CHARD. See **Acelga.**

CHAYOTE, Tayote; Christophine; *Sechium edule*, (Jacq.) Swartz.

One of the commonest and best native Porto Rican vegetables. Boiled, baked, stewed with roots or meats, or (especially) "stuffed", it fills a place which no other plant can occupy. It succeeds best in the cooler, moister districts; a trellis or tree support is almost necessary; many fruits do not germinate and the young vine frequently lacks vigor; 3–10 m.

There are fruit forms ranging in size from 8 to 20 cm. in length; from smooth to exceedingly prickly; and from creamy white to green in color; these forms, however, are not named and it is probable that none of these ten or twelve "varieties" is absolutely stable. The root, if not too old (and woody) is quite edible, resembling a poor Water Yam when boiled. Exportable.

CHESTNUT, MORETON BAY. See **Castaño de Australia.**

CHERIMOYA; Cherimoyer; *Annona cherimolia* Mill.

Recently introduced and extremely rare Central American first-class fruit tree. Will probably succeed in high valleys of the interior.

CHERIMOYER. See **Cherimoya.**

CHERRY. See **Cereza.**

CHERVIL. See **Cerafolio.**

CHICHAROS; Bonavist Bean; *Dolichos Lablab* L.

Commonly cultivated in nearly all parts of the Island. Not marketed here in large quantities, but could be exported in wholesale lots since the demand is strong in New York for this first-class old bean; probably from Tropical Africa. Five varieties were brought in from St. Thomas in March, 1924; and about three kinds were in evidence theretofore. The plant usually produces a fairly steady crop for 6 to 10 months or more; generally trellised or allowed to run on fences or trees. All things considered, this is one of the best, if not the best species of bean for the garden. The flavor of some varieties is exquisite.

CHICKORY. See **Achicoria.**

CHICKPEA. See **Garbanzos.**

CHILLI. See **Ají Grande.**

CHINA, Naranja Dulce; Orange; *Citrus sinensis* (L.) Osbeck.

Whereas the exact place of origin of this very old fruit will probably never be known, it appears certain that the Portuguese spice traders first brought it from some port on the South China Coast to Europe at the beginning of the 15th century—400 years after the Arabs had taken the Sour Orange to Sicily. The Spaniards began cultivating the sweet orange probably about the middle of the 16th century, and they distributed it to Florida and their West Indian Colonies at that time

Today the species is practically naturalized here in the mountainous coffee region. Several races may be distinguished which come true to seed, and in fact, very nearly all the trees of the so-called "wild orange" are "volunteer" seedlings. While there are but very few orchards of these semi-cultivated wild sweets, or "Chinas", the number of scattered trees in and around the coffee plantations is tremendous; in the 1922–23 season over 300,000 boxes of this "wild" fruit were exported from the west end (and Ponce) of the Island, yet probably not 65 per cent of the total crop was shipped. In this connection it should be remembered that these "wild" trees are never pruned or sprayed, and many of the trees are so old (50 years, presumably) and their fruits are so small and so difficult to pick that they are abandoned. Many small packing sheds have been established along the roadways; mules and horses carry the bulk fruit down from the "fincas" to these sheds, and trucks then take the packed crates down to the coast; for many years the fruit went down to the ports (Mayagüez and Aguadilla, mostly) in ox-carts and on pack animals, the spoilage, of course, being excessively great; yet, because of the extremely low price of these excellent oranges the shippers could compete with the grafted orange growers.

The common China, produced very largely in the 150 square miles of territory in the western end of the Island, is a medium-sized, well colored fruit with a moderate amount of "rag", a good tough peel, and a sprightly, pleasant flavor.

A "native" Navel variety (or perhaps *several*) was discovered east of Mayagüez in 1903.

Several practically seedless sorts have been found.

The annual production of the seedling China trees is from 250,000 to 500,000 boxes; heavy and light crops usually alternate.

The crop of grafted oranges, mostly from the Bayamón and Manatí–Vega Baja sections, runs from 1,000,000 to 1,500,000 cases. The acreage in 1920 was about 1,300; number of trees, about 100,000. The grafted (named) varieties were practically unknown during the Spanish régime; in 1900 a large (500-acre) tract near Palo Seco was cleared and planted with the standard Florida varieties; Mr. William Allan was the pioneer in this industry which soon (1904–1910) spread along the north coast, but never reached the famous fruit district of the western end. Little extension of the groves has been evidenced since about 1910. Many of the first orange groves were uprooted and replanted about 1908 to 1912 with grapefruit.

The following varieties are established here:

Jaffa, reputed to have been brought from Jaffa, Palestine; round, deep colored; juice abundant; seeds many, large.

Joppa, a seedling (at San Gabriel, Calif.) from a Palestine orange was the parent (1877); oblong, slightly shouldered; skin thin, pebbled; sweet, fine flavor.

Lue Gim Gong; the most popular of several varieties of oranges which hold their fruits for several months after ripening; color deep orange; very juicy with no "rag", flavor sub-acid, quite sweet when fully ripe; nearly seedless.

Mediterranean Sweet, and old (1870) California favorite; fruit round or oblate, small to medium-sized; tree semi-dwarf.

Norris, a rare old (1880) variety from Glenwood, Fla., round, early ripenning; very smooth skin, yellow tinged with deep red, nearly seedless; very juicy, "melting" pulp.

Parson Brown, introduced about 1878 at Lake Weir, Fla.; size medium to large, quality fair; very popular here.

Pineapple, originated near Citra, Fla.; color deep red; flavor and odor suggest pineapple; one of the commonest here.

Ruby, Ruby Blood; an old Mediterranean variety, fairly popular here; color or rind very good, but the pulp seldom becomes red here.

St. Michael, Paper Rind; an old variety from St. Michael; small, very thin-skinned, juice abundant, but not well colored here.

Valencia, Hart's Late, Tardiff; An old favorite from the Azores Islands; introduced to the mainland in 1870, but probably not in evidence here till 1900; shape somewhat irregular; seeds very few, inclined to sourness; one of the best shippers and prolific, the most popular variety in the grafted groves.

Washington Navel, Bahia, Riverside Navel (wrongly called "Nebo" and even "Neighbor"); this "King of Oranges" was introduced in 1870 from Bahía, Brazil to Washington, D. C. It is inclined to pithiness and coarseness here. The sub-races are:

Australian, (with a thick skin, often closed navel; probably from Australia).

Buckeye, (with ridges of deeper color; from San Dimas, California).

Navelencia, (thin-skinned, large; from Duarte, California).
Nugget, (with a crack in the skin; from San Dimas, California).
Thompson, (early, of excellent appearance; introduced at Duarte, California, in 1891).

CHINITA, Limoncito; Sweet Lime, Lime-berry; *Triphasia trifolia* **(Bourm. f.) P. Wilson.**

This widely naturalized East Indian shrub (1–2 m.) is often planted in gardens and sometimes escapes. The sweet mucilaginous pulp and the very aromatic oily peel of the small (1–1.5 cm.) red berry are edible and may be made into jam, marmalade, etc. Deserves a place in every collection.

CHIVE. See **Cebollin.**

CHRISTOPHINE. See **Chayote.**

DAHLIA DE AZUCAR; Sugar Dahlia; *Dahlia pinnata* Cav. (?).

Three varieties of a sweet-rooted dahlia were presented by the New York Botanical Gardens in 1924; these have succeeded fairly well at Cayey and Vega Baja Model Farms. The roots contain inulin, like those of the Girasole (*Helianthus tuberosus* L.); apparently they cannot compete with the Girasole.

DASHEEN DE AZUFRE; Sulphur Dasheen; *Caladium sp.*

Introduced from Dominica in 1924; of very uncertain origin; has long been cultivated in the little-known interior of that island, but is now rapidly being superseded by the far more prolific Trinidad Dasheen. Planted along banks of streams. Forms large stools, 10–20 side-shoots sending up leaves beside the old corm. The fecula of the mature corm is distinctly yellowish, somewhat resembling that of the (Hawaiian) Manaa Taro. The petioles show considerable reddish and bronze color below but are, on the whole, paler than those of most Colocasias.

DASHEEN DE TRINIDAD; *Caladium Colocasia* var. *esculenta* sub-var. *globulifera* Engl. & Kr.

This extremely productive root-crop was brought in 1903 by the writer from Trinidad, B. W. I., to the U. S. Experiment Station at Mayagüez; it was sent from that Station in 1905 to the U. S. Department of Agriculture whence it has been distributed throughout the Southern States as one of the principal introductions of the Office of Foreign Seed and Plant Introduction.

Since many similar varieties and sub-species occur only in the Orient and few if any are proved to be endemic in Tropical America, it most probably was introduced in Trinidad, in some mysterio manner, from the Far East in the early days of that Island's colon zation.

Unlike the common Malanga, this Dasheen bears numerous (20 t 100) side cormels, or globose tuberous rhizomes, close to the mothe rootstock; both corm and cormel contain a fine-grained fecula lik that of the best Taros. No better root-crop for moist lands in th Tropics exists.

Although this important economic plant was introduced 22 yea ago, it is only just beginning to enter into the list of crops grow by the Island's farmers. A new lot of cormels was sent (from th U. S. Department of Agriculture) early in 1924 and a re-introdu tion was made from Trinidad in November, 1924; four of the Mode Farms are now propagating it for general distribution.

The yield per hectare should be about twice as heavy as for th best Yautías.

One of the greatest advantages of the Trinidad dasheen is it remarkably short season—6 to 8 months, instead of 9 to 12. It adaptability to a great variety of soils is another strong point. Th cormels and corms keep very well after harvesting.

DATE. See **Palma de Dátil.**

DATIL. See **Palma de Dátil.**

DIENTE DE LEON; Dandelion; *Leontodon Taraxacum* L.

A very common European spinach vegetable. This is behavin well at Trujillo Plant Propagation Station.

DILL. See **Eneldo.**

DURIAN; *Durio zibethinus* L.

This Philippine (and Malayan) tree, in the author's opinion deserves to rank practically on a par with the mangosteen as th world's best fruit; 10–20 m. Introduced in 1920 at the U. S. Ex periment Station (several specimens in evidence), and in 1924 a the Trujillo Plant Propagation Station. While only one (?) tre has succeeded well in the Western Hemisphere (Dominica Botan Gardens) to date it is probable that this excellent fruit will giv satisfactory results in this Island.

The fact that its odor is strongly disliked by many people i only a negative factor as against its exquisite taste and its very high degree of nutritiousness. The pulp of the fruit, somewhat resem bling in texture that of the Avocado, has three distinct flavors first, the highly aromatic, almost resinous flavor; second, the rich cheeselike, satisfying taste; and third, the indescribable quality which makes Durian pulp more avidly relished than that of perhaps any other fruit. The fruits weigh from 1–3 kilos.[*]

EGG-FRUIT. See **Canistel.**

EGGPLANT. See **Berenjena.**

ENDIVE. See **Escarola.**

ENEA; Cat-Tail; *Typha angustifolia* L.

This old cosmopolitan aquatic is common in fresh-water bogs and wet soil along streams, especially near the east coast. The long fleshy roots contain about 8 per cent of starch and according to tests made at the By-Products Plant in Mayagüez a fair cattle and pig feed can be made (as in Europe) from them; the cost of labor here now for digging the rootstocks is prohibitive.

ENELDO, Hinojo; Dill; *Anethum graveolens* L.

This European culinary herb is not very common but should be grown everywhere. Both seeds and foliage are excellent for "seasoning".

ESCAROLA; Endive; *Cichorium Endivia* L.

This Indian salad vegetable is very rarely cultivated here.

ESCHALOTA; Shallot; *Allium ascalonicum* L.

A rare, onion-like vegetable, sometimes cultivated though seldom seen in the markets. Closely related to Chive but milder in flavor; the angular, oblong bulbs distinct but clustered. Probably Asian in origin.

This rare root crop from Central and Southern Europe is in evidence at Cayey Model Farm where it appears to succeed fairly well.

ESPARRAGO; Asparagus; *Asparagus officinalis* L.

This excellent vegetable (originally wild in Europe, with similar species in East Africa) is rarely planted here; the roots usually weaken after two or three years. The flavor of the young shoots here is strong.

ESPINACA; Spinach; *Spinacia oleracea* L.

This rather recently introduced salad does fairly well even in full sun when proper soil conditions are met.

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[*] The 4 or 5 (or more) other species of Durio which occur in Brunei, Sarawak, and presumably Dutch and British North Borneo should most certainly be introduced as soon as possible The fruits of these (not yet cultivated) fruit trees have little or none of the objectionable odor of the common Durian

ESPINACA SIN AROMA; Herb Patience, Spinach-Dock; *Rumex Patientia* L.

A rare European salad plant being introduced through the Plant Propagation Station.

ESPINACA SIN AROMA; Herb Patience, Spinach-Dock; *Rumex Patientia* L. *pansa* Murr.

A splendid spinach becoming popular in limited areas here. The plants readily reach a good size and furnish over a long harvest period good crops of the tender branches which find a ready sale to steamers and occasionally to large grocery stores; 0.5–1 m. Native of New Zealand.

ESPONJA; Luffa, Vegetable Sponge; *Luffa cylindrica* (L.) Roem.

The young fruits of this and of the much rarer species *Luffa acutangula* (L.) Roxb, are rarely eaten in stews and mixed with rice.

FEIJOA; *Feijoa Sellowiana* Berg.

A rare South American fruit shrub; introduced about 1904 at the U. S. Experiment Station in Mayagüez, but has never succeeded well anywhere to date. This, being so closely related to the guavas, should be thoroughly tested both for its edible flowers and highly fragant fruits.

FENNEL. See **Hinojo.**

FIG. See **Higo.**

FIG, INDIAN. See **Tuna Mansa.**

FRAMBUESA AKALA; Akala Berry; *Rubus Macrei.*

Received in January, 1925, from the U. S. Department of Agriculture, and planted out on a private plantation near Bayamón. Also plants of apparently two varieties of this fruit have been received (January, 1925) at the Experiment Station at Río Piedras. This excellent Hawaiian species should prove of great value in our *Rubus* work.

FRAMBUESA AMARILLA; Himalayan, or **Golden Evergreen, Raspberry;** *Rubus ellipticus* Smith.

Introduced recently by the Río Piedras Experiment Station from Jamaica; of Asiatic origin. Plant erect, 3–5 m.; fruit yellow, small; plant usually large and very vigorous,—of probable advantage in our hybridizing work.

FRAMBUESA AMERICANA; Red Raspberry; *Rubus idæus* L.

Recently introduced from the mainland. Does not endure the climate well at the Río Piedras Experiment Station, but may succeed at the Cayey, Utuado, and San Sebastián Model Farms.

FRAMBUESA DE AUSTRALIA; Australian Raspberry; ***Rubus sp.***

Introduced by the U. S. Experiment Station about 1911; fruited well in 1912. Promises well.

FRAMBUESA COMUN, Zarza, "Fresa"; Mountain Raspberry; ***Rubus rosæfolius*** **Smith.**

Very common on moist mountain slopes, especially at east end of the Island; occasionally cultivated (Bayamón). From southeastern Asia; date of introduction very uncertain. Crop almost continuous; at Aibonito baskets of fresh, brilliant red berries are offered for sale at the roadside every day in the year. Berries frequently marketed.

Being tested for variability and "sports"; may be used in *Rubus* hybridizing work of Department. Color excellent; size fair but variable; flavor distinctive though not liked by some.

The so-called "Balloon Berry" is an "improved" form with large, odd-shapped fruits. Some forms at the Cayey Model Farm have fruits 3–4 cm. in diameter.

FRAMBUESAS MISCELANEAS; Various Raspberries.

The following 12 *Rubi* have recently been planted out at the Río Piedras Experiment Station.

Rubus Thunbergii; from China.
Rubus moluccanus L. var. *Fairholmianus.*
Rubus moluccanus L. var. *macrocarpus.*
Rubus trivialis. Mich. The Dewberry of the Mainland.
Rubus hybridus. A hybrid between *R trivialis* and a blackberry, grown in Florida.
Rubus fructuosus; Bot. Gardens, Ceylon.
Rubus glomeratus; Bot. Gardens, Ceylon.
Rubus innominatus S. Morre.
Rubus lasiostylus Focke.
Rubus adenophorus Rolfe.
Rubus coreanus Miq.
Rubus melonasius.

From U. S. Department of Agriculture.

FRAMBUESA NEGRA; Blackcap Raspberry; ***Rubus occidentalis*** **L.**

Recently introduced. Will probably not endure the lowland temperatures well.

FRAMBUESA DE NIEVE; Snow Berry, ***Rubus niveus*** **Thunb.**

One of the very interesting *Rubi* from China, of recent introduction (at the Río Piedras Experiment Station).

Fruits red, orange, or bluish black.

FRAMBUESA DE QUEENSLAND; Queensland Raspberry; ***Rubus probus*** **Ba ley.**

Introduced by the U. S. Experiment Station. Resembles the common "fresas" berry, but larger. Promises well.

FRAMBUESA DE LOS ANDES; Purple Raspberry, Andean Berry; *Rubu glaucus* Benth.

This splendid species, recently introduced by the Insular Experiment Station, from northern South America, bids fair to become one of the best *Rubi* under cultivation here. The beautiful fruit is comparatively large (1.5–2 cm.) and the plants are very vigorous Fruit black or purple.

FRAMBUESA DE HAWAII; Akala Berry; *Rubus hawaiensis.*

Perhaps some forms of this (and the closely related species, *R Macrei*), are the largest of all the many *Rubi*—even larger than the enormous Colombian wild raspberry (*R. glaucus* Benth.), some fruits, according to Mr. J. P. Rock, the famous explorer and plant collector in Southern Asia, reach a diameter of 5 cm. There are several forms, some with yellow fruits some with fruits of a beautiful purple shade; and some varieties grow to enormous size.—5–7m. in length.

FRESA; Strawberry; *Fragaria chiloensis* Duchesne.

Date of original introduction not known; but a variety apparently adaptable to tropical conditions was planted out in 1923 at Río Piedras Experiment Station, the Trujillo Plant Propagation Station, and elsewhere. The plants grow well and at times bear fairly good crops of medium-size berries. Numerous seedlings of this variety are being tested by the Plant Breeder, Mr. J. P. Griffith, at the Río Piedras Experiment Station; some of these are expected to show complete tolerance of our climate. Other varieties might adapt themselves more readily.

FRESA. See Frambuesa Común.

FRIJOL; Cowpea; *Vigna unguiculata* (L.) Wolf.

Probably of recent introduction, native of Tropical Africa. As a forage and food-plant it seems to be slowly gaining in favor. Numerous varieties have been tested, by the U. S. Agricultural Experiment Station, the Río Piedras Experiment Station, and the Trujillo Plant Propagation Station; the varieties which appear best adapted to Porto Rican conditions are: New Era, Iron and Groit.

Several of these varieties mature in 60 to 70 days.

GALLITO, Báculo; *Agati grandiflora* (L.) Desv.

This peculiar (monotypic) tree, 4–10 m., from Tropical Asia, is extremely common along roadsides and around gardens. The edible (boiled) fleshy, large flowers, and the half-ripe pods are seldom used here as they are in other countries.

The red-flowered form is very rare here.

GANDUL; Pigeon Pea, Congo Pea; *Cajan Cajan* (L.) Millsp.

Potentially the most important food and forage plant of the Island. Country of origin unknown, and date of introduction (if any) uncertain.

While in Hawaii this is strictly a forage crop, it is here grown almost entirely for its seed (used either green or ripe); there the acreage is over 10,000, here probably under 8,000. Near Ponce the first Gandul pasture in the Island is succeeding well; the plants endure drought well and recover promptly from heavy browsing.

The most striking introductions at Trujillo Plant Propagation Station have been: "New Era" and "New Era, Strain D", from Hawaii Agricultural Experiment Station, "Florida" and "India" from the U. S. Department of Agriculture at Washington, D. C.—the latter being the tallest (4–5 m.) variety known.

The following varieties have been tested at the Trujillo Plant Propagation Station and the Model Farms:

Amarillo; a common variety from the Lares district of medium-size, very prolific, rather late in bearing. The pods are long, pale purple, and the ripe seeds are a yellowish brown color. The leaves are very dark green.

Americano; a variety from the Río Piedras district, with pods having cross stripes of violet and brown; seed is large, white, with orange-colored spots.

Blanco; this is probably the commonest of our "native" Gandules and is even exported in considerable quantities to the mainland. The pods are long with brownish sutures and stripes. Seeds gray with a dark hilum; plant very resistant to rust and good yielder. Two or three forms recognized.

Blanco Chiquito; one of the famous Yauco-district varieties, with a comparatively small pod striped with brownish marks: the seed is gray like the regular Blanco, the principal difference between these varieties being in the size of the pods.

Chágaros; a large plant of good branching habit from the south side of the Island; flowers yellow striped with dark red; pods dull green covered with spots. Seeds large, grayish white with orange stains. Very susceptible to rust.

Chino; this common variety from the Yauco district is of good size and has reddish flowers, very dark colored pods and seeds of an orange or grayish color with a distinct large spot near the hilum. It fruits in six months and may be planted at any time of the year.

Colmeno; a common (Yauco district) variety with very large grayish seeds.

Dominica; one of the varieties brought from Dominica Botanic Gardens has given excellent results. The seeds are shining orange color, round, and of good size; the pods are green, blunt and of good size.

India; this variety was received in 1923 from the U. S. Department of Agriculture. It is apparently the largest of all known gandules, plants at the Trujillo Plant Propagation Station reaching a height of 5 m. by the end of 1924. The pods are very small, the seeds are unusually small with a yellowish color when dry. Flowers reddish.

Largueño; a variety from the north side of the Island having slender light green pods and medium-sized white seeds.

Manchado; a first-class variety having the pods spotted with brown and yellowish colors; the seed is of a beautiful bright orange color.

Miami, or *Florida;* this plant was received from the U. S. Department of Agriculture in 1923. Flower reddish; pod spotted; seed small, dark orange in color. This plant is rather slow in bearing and only moderately susceptible to the rust blight.

Morado; a variety from the Lares district, with very large pods and reddish purple seeds with a white hilum. Usually a dwarf plant.

New Era; from the Hawaii Experiment Station; this variety was received there from the U. S Experiment Station in Mayagüez in 1903 and was bred up between 1910 and 1915 into a very prolific strain which was received back into Porto Rico in 1923 where it has given splendid results at the Trujillo Plant Station. This variety is comparatively wide-spreading, and the slender long branches, when in good crop, bend down to the ground. The seed is roundish and dark, while the pods are green. This variety is very susceptible to the leaf rust or "blight".

New Era, "Strain D"; very similar to the regular New Era but is supposed to be about three weeks earlier.

Parranetos; a distinct variety having short broad pods like those of the Lima bean, of a pure green color changing to yellowish when ripe; the seeds are of good size and of light orange color

Pinto Moro; the pods are brownish with yellowish markings and the seeds are small and white.

St. Kitts; among the several introduced from St. Kitts and the neighboring islands in 1924, one variety has given excellent results and is being distributed. The flowers are small and pale yellow, while the pods are pale green, of good size; and the seeds are white, somewhat flattened, but rather large.

Todo Tiempo; a comparatively small erect plant with brownish-yellow flowers; small, flattened, tan seed; pods half green, half black, rather resistant to rust. The striking feature of this variety is its very early fruiting habit and its frequently repeated light crops of seeds.

Viequero; a variety from Vieques and the east end of the Island; pods very short and small; seed small, roundish, brown, with a short white hilum.

Among the other varieties under test at the Trujillo Plant Propagation Station are: Gigante, Cangrejero, Sanjuanero, Patebuey, Ponceño, Multicolor, Colorado, St. Thomas, and about six or eight other unnamed sorts of doubtful position in our agronomy. The total number of distinct gandul varieties at present under general cultivation here is probably between 20 and 25.

At the By-Products Plant in Mayagüez the half ripe seeds have been successfully dehydrated *with the skin intact;* when soaked in water a few hours these seeds regain their size and without loss of the "fresh taste" may be cooked as easily as fresh seeds. The leaves and young branches when dehydrated and ground make a cattle feed about equal to alfalfa meal; the analysis shows a protein content of 29.8 per cent; of crude fiber, 17.5 per cent, and of carbohydrates, 31.3 per cent.

Experiments at the Farms and Trujillo Plant Propagation Station indicate that the Gandul may be "topped back" several times without injuring the vigor of the plant. In Hawaii it is reported that as a pasture forage it may be "fed off" (by cattle or horses) for five to seven years without replanting. The normal life of the plant here is 1 to 2 years. Both the ripe seeds and the entire nearly ripe pods (like "string beans") are exported in considerable quantity to New York; the latter article is a recent venture thus far in the hands of only two or three exporters.

GARBANZOS; Chick-Pea; *Cicer arietinum* L.

Very rare, practically always a failure in cultivation here. Probably native to Mediterranean region. Heavy imports from Spain; selected seed imported by Spain from Mexico (Guadalajara district).

GARCINIA; *Garcinia tinctoria* (DC.) Dawn.

This handsome species was sent out about 1908 from the U. S. Department of Agriculture; a fine specimen is in evidence in the old Dr. Leonhart collection near Bayamón—now known as Villa

León and another is in Mr. H. I. Sewall's ground at Naguabo; 6–9 m. The fruits are 5–10 cm. in diameter, bright yellow and smooth skinned; the yellow pulp is very juicy, strongly acid, but of a very pleasing taste; one or two seeds. The fruit keeps very well; perhaps exportable.

GARCINIA ESPINOSA; *Garcinia spicata* Hook. f.

This Malaysian species was experimentally planted at the Insular Experiment Station in 1924.

GARLIC. See **Ajo.**

GENIPAP. See **Jagua.**

GHERKIN. See **Pepinillo.**

GINGER. See **Jengibre.**

GIRASOL; Sunflower; *Helianthus annuus* L.

This old Composite originated in Central United States is now spread throughout not only the Temperate Zone but is invading the Tropics; 1–3 m.; two forms under cultivation here but not planted to any extent. The seeds are frequently used for feeding poultry but the forage is seldom used here. No oil is made from the seed

GOOSEBERRY. See **Grosella.**

GOOSEBERRY. See **Hortensia de Bajuco.**

GOURD. See **Güiro.**

GRAMA; Bermuda Grass; *Capriola dactylon* (L.) Kuntze.

Cosmopolitan; probably the widest-spread grass in the world today. Propagated by cuttings. Spreads rapidly on dry ground. Does not endure heavy pasturing.

GRAMA BLANCA; St. Augustine Grass, Running Crab Grass; *Stenotaphrum secundatum* (Walt.) Kuntze.

This cosmopolitan pasture and lawn grass is one of the commonest species in the Island. The flattened, thick, sweetish, creeping stems attain a length of 3–5 m. in good, moist soil. A white-variegated race is cultivated as an ornamental.

GRANADA; Pomegranate; *Punica Granatum* L.

Very common third-class South Asiatic fruit-shrub, 2–4 m.; cultivated everywhere, but never in orchards. Several varieties, some having white, some red, flowers, are in evidence. The juice of the pulp cells is used for coloring and flavoring drinks. Occasionally eaten "out of hand".

GRANADILLA; Grenadilla; *Passiflora quadrangularis* L.

A very large vine from Central America, frequently cultivated in all parts of the Island; fruit by far the largest in the genus, more or less square with rounded angles, 10–25 cm. long by 8–15 cm. in diameter: the walls of the fruit are spongy or nearly firm, practically tasteless, but sometimes used in the preparation of dulces; the comparatively small cavity is partially filled with a mass of flat seeds enclosed (each) in a watery, sweet, aromatic pulp, the juice of which is used in preparing sherbets and drinks, or eaten raw.

GRAPE. See **Parra.**

GRAPE. See **Uva.**

GRAPES, CHIGGERY. See **Nigua de Monte.**

GRAPEFRUIT. See **Toronja.**

GRASS. See **Grama.**

GRASS. See **Malojillo.**

GRASS. See **Yerba.**

GRENADILLA. See **Granadilla.**

GROSELLA; Otaheite Gooseberry; *Cicca disticha* L.

Probably introduced long ago from the Orient, very common tree semi-cultivated throughout the Island. 4–8 m. The fruit, borne during the dry season, may be eaten raw, notwithstanding its intense acidity, and is especially good cooked up into jelly or conserve with sugar. When cooked with sugar this yellowish fruit becomes dark red in color The decoction of the fruit is used in a popular drink, sweetened and iced, the fruit being discarded after a short period of boiling.

GRUMICHAMA; *Eugenia Dombeyana* Skeels.

Recently introduced (through the U. S. Department of Agriculture) second-class fruit tree, 5–8 m. Distributing from Plant Propagation Station. Probably a valuable addition to our collection of Eugenia fruit trees.

GUAMA; *Inga laurina* (Sw.) Wild.

This very common (probably indigenous) coffee-shade tree (8–15 m.) produces greenish, leathery pods containing a white sweet watery pulp surrounding the large green seeds. These pods are commonly marketed in the coffee districts. Apparently not variable.

GUANABANA; Soursop; *Annona muricata* L.

First-class fruit tree, 3–6 m.; commonly cultivated throughout the Island. Fruits ranging from 0.5–1.5 kilos, extremely common in markets nearly the entire year. Eaten fresh, as dessert fruit, or the pulp used in drinks and sherbets. Soft rind and great weight prevent long-distance transportation; if picked green may be kept a week or more. Very slightly variable. Fruit frequently attacked by insects. Worthy of intensive cultivation and hybridization. Probably native.

GUANABANA CIMARRONA; Mountain, or Wild, Soursop; *Annona montana* **Macf.**

As a wild fruit practically valueless, but an excellent fruit, believed to be of this species, has been introduced by the Department from St. Thomas, A. V. I., where it is cultivated at Botany Bay.

GUANGO. See **Samán.**

GUAR; *Cyamopsis psoralioides* DC.

This very old Indian crop resembles the gandul in some points, but its growth is slower and the plants in the Department's testing plats reach only 1–1.5 m. The seeds (especially unripe, like the Gandul) and the young pods (like "string beans") are boiled for human food; the foliage is a rich fodder.

GUASAVARA; *Eugenia æruginia* DC.

This indigenous tree of the waste lands in central Porto Rico has a height of 20 m., and bears an oval or roundish, purple fruit, 10–15 mm. in diameter.

GUASAVARA. See **Caimitillo.**

GUAVA. See **Guayaba.**

GUAVA-BERRY. See **Murta.**

GUAYABA; Guava; *Psidium Guajava* L.

Several varieties of this native species are common throughout the Island and in point of numbers this vies with the Jobo as the commonest semi-cultivated fruit tree in the Island; 3–10 m. At least six distinct varieties are in evidence in private and government institutions here; the small sweet, the small sour, the large round, the large pear-haped (rare) and other minor sub-varieties are in evidence. On account of a peculiar fungous disease ("mummy disease") the wild trees are frequently not very prolific, some producing practically no edible fruits at all. The fruit is used largely raw but is also cooked in the form of dulces, preserves, and especially made up into a paste, a "crystal" or jelly, and a jam which to some extent are exported to the mainland. Also common in *helados*.

GUAYABA DE FRESA; Strawberry Guava; *Psidium cattleianum* Sabine.

This first-class little fruit tree (native to Brazil) was introduced about 1900 from Florida by one of the largest fruit growers here; it has never been popular and only a very few specimens are in evidence. The fruit, although not very prolific, is one of the best-colored fruits in the world and the flavor is well above the average. Should be in every collection.

GUAYABA SILVESTRE; Wild Guava; *Eugenia pseudopsidium* Jacq.

A shrub or small tree, 8–12 m., in waste lands in the interior districts of Porto Rico and Vieques; fruit roundish, red, smooth, 10–15 mm. in diameter.

GUAYABOTA-NISPERO; *Maba Sintenisii* Krug. & Urban.

A fairly common tree from the mountain forests, endemic to the west central district. Fruit roundish, brown, about 3 cm. in diameter, with several seeds.

GUAYAVITA. See **Malagueta.**

GUINEA-CORN. See **Millo.**

GUINEO, Banano; Banana; *Musa sapientum* * L.

While wild species of *Musa*, for the most part nearly or quite inedible, are in evidence throughout most of the frostless regions of Africa, southern and southeastern Asia, the East Indies, and Polynesia, it appears fairly certain that the edible bananas and plantains which the Spaniards brought to Porto Rico in the 16th century came (westward) from northern and western Africa and the Canary Islands rather than (eastward) from the Orient. Just how they came and which varieties arrived first will probably never be known; if records of those important events were ever made it seems that all have been lost. The first reliable reference to these fruits in Tropical America is given by one of the Spanish narrators (Las Casas?) early in the 16th century; he mentions, very casually, in deed, the dispatch of some boats, manned by the crew from a vessel

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* The local name, Guineo, would seem to indicate that the early colonists simply applied to the strange new fruit the name of the region—Gulf of Guinea—whence they were beginning to obtain several new commercial items, including slaves,—just as the Dasheen, or De la Chine, or Des Indes, was named for the supposed region of its origin. Quite possibly it was in the first slave ships that there arrived here not only the "Fruta de Guinea", but also the Ñame de Guinea, and the Yerba Guinea.

In the French West Indies, the local name Figue is applied to most types of Bananas, apparently with no very good reason, since dried bananas (*banana "figs"*) were undoubtedly unknown at the time the misnomer originated just arrived at Trinidad, up a river (evidently the Orinoco) for the purpose of securing a supply of fruits for the said vessel. How such large supplies were readily available *up a river* and not at the coast of Trinidad itself is a very perplexing problem.

There is little doubt, however, that the only plant closely related to the banana and plantain in evidence here (or elsewhere in Tropical America) in pre-Columbian times was the Bihai, or Wild Plantain (*Bihai Bihai* [L.] Griggs); and this was of questionable importance as an emergency-ration root-crop.

After the plantains, the bananas (as a class) follow second in importance as food fruits; unlike the mango and avocado they are on the market every day of the year.

The young leaves are eaten by cattle and goats. The inside portion of the pseudo-stem is sometimes chopped up and fed raw to pigs. The bulb-like base of the "stem", cut up in pieces, can be used like the stem middle; but at the By-Products Plant in Mayagüez a fairly good swine and cattle feed was prepared by slicing, drying and grinding the "ñames" of several sorts of bananas; about 5 kilos of raw root are required to yield 1 kilo of dry flour.

The heart of the flower-bud, or *pámpana,* is not used (boiled) as a table vegetable here—as it is (of some varieties) in the Philippine Islands.

Accurate data regarding the source and date of introduction of the 12 or more old (*sic*) varieties of these exceedingly important food plants of Porto Rico would be of great importance.

Since 1901, the date of the establishment of the Federal Agricultural Experiment Station here—first in Río Piedras (in October) then in Mayagüez (in April 1902)—some 15 or 20 varieties have been received, mostly from the Jamaica Department of Agriculture and the U. S. Experiment Station at Honolulu, H. T.; a few suckers of several of these Indian (*via* Jamaica) and Polynesian fruits were distributed from the U. S. Experiment Station and may still exist in the Island, but it appears that nearly all of the said varieties were unfortunately lost. Among those lots were the famous Hua Moa, or Egg Banana, of Hawaii, with excellent fruits about the size and shape of a turkey's egg; the Rajah, a choice Indian variety similar to our Rosa; and the Martaban.

In the fiscal year 1904–5 the following very interesting varieties were presented by the Agricultural Experiment Station at Honolulu, H. T.: Hai, Kapua, Maole, Lele, Ae-ae, Popoulu, Brazilian, Apple, Striped.

Presumably several if not all of these were distributed from the Federal Experiment Station at Mayagüez; only the Hai, however, appears to be in evidence now at that Station (and at Vega Baja Farm and Trujillo Plant Propagation Station).

At the end of the said fiscal year there were no less than 68 varietal names of bananas and plantains in the collection at the Mayagüez Station.

The estimated annual crop is about two million bunches.

Deplorable confusion of varietal names has long existed, not only here, but in the Orient as well; the synonymy work (to determine just which varieties were really distinct), begun at the U. S. Experiment Station in 1903, was not completed.* Actually, only four types of true Bananas are in general cultivation here now. The varieties now in evidence here are:

> *Colorado;* one of the commonest and cheapest of our bananas; also the largest,—attaining 8 m. or more in rich moist soils in mountain ravines. The reddish or brownish-purple coloring of the "stem", midrib, and fruit is deeper, perhaps, than in any other Banana, though many have as highly colored fruits and some have darker leaf-bases.

The quality of the sub-cylindrical, blunt-ended fruit is very poor and is not considered as safe, even when quite ripe, for eating raw; baked in its skin and served hot with butter and spices it is not a bad table fruit. Excellent cattle feed was made at the Mayagüez By-Products Plant from the nearly ripe fruits—by running the entire bunch through a forage-cutter, dehydrating, and grinding; at 15 to 25 cents per hundred fruits the cost of this highly nutritious meal was around 7 cents per kilo.

This variety requires 12 to 15 months to mature. It is highly resistant to disease.

Colorado Blanco; this is merely the green form of the Colorado. No part (except the "pámpana") has any of the purple color. The ripe fruit has the same pasty or slimy pulp as the Colorado. The odor of the well-ripened fruit is better than that of most other West Indian bananas, though not to be compared with some of the fragrant Oriental varieties.

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* During the period of 1911 to 1914 the author built up for the Bureau of Agriculture of the Philippine Government, the largest collection of Musa varieties ever assembled with the object of determining their synonymy by noting what differences, if any, existed among the various members of the many groups or types, all grown in one field under identical conditions Success could not attend such a task except under very favorable circumstances; yet the need for such a work was and still is urgent Nearly complete collections of the Bananas and Plantains of Papua, Siam, Indo China and the Philippine Islands (the countries richest in musaceous floræ) were received (*gratis*)—some 50 or more varieties from each country; and most of the other tropical countries likely to furnish valuable material donated their quota Over 730 names were indexed, after discarding a large number of obvious synonyms; some 15 countries were represented, several new types of these fruits were brought to light; and many botanically new species, sub-species, and varieties were (some time afterward) described; probably not less than 300, and perhaps around 400, distinct forms of these plants were in evidence Possibly 100 others, in out-of-the-way corners of the Old World Tropics, still await the courageous pomologist.

Less common than the Colorado, or at least much less conspicuous. Grown in the coffee plantations.

Dátil, Guineíto, Niño, de Rosa; Lady's Finger, Fig Banana; whether 1, 2, or 3 really distinct forms are included under these names, is at present debatable; only a prolonged test. growing several "cepas" of each reputed sort side-by-side with all the others in the same soil, can solve this question.*

The plant is of medium size (3.5–5 m.) but rather slender and weak. Fruits in 11 to 13 months. Resists fairly well the fungus diseases.

The extreme sweetness and delicate flavor of the pulp, its thin peel, delightful perfume (when thoroughly ripe) and dainty appearance have won for this excellent fruit the first place among all table bananas here; yet the bulk of the bananas marketed are, or course, of the Guarán variety. Dátiles are especially good fried in oil or butter—one of the few items on our menus which we never tire of.

Peeled and dried whole these splendid little fruits are an excellent dessert confection; they are sometimes sold as "banana figs"; at the By-Products Plant in Mayagüez some difficulty was experienced in determining the right stage of ripeness at which to dry, the correct temperature (to hold the fresh fruit flavor), and the degree of dehydration (to avoid fermentation on one hand and over-hardness and darkness of color on the other).

A teratological "freak" variety, known as the Tirabuzón, or Corkscrew, has the hands arranged in a continuous *spiral* on the rachis.

The magnificent Rajah (from India) and the several rosy or purplish-fruited races should be in evidence here; the Rajah fruited here first in 1904; the one (?) Purple Date plant was destroyed about 1902.

Guarán, Gigante; the very common large-fruited variety which for thirty years has been the *piece de résistence* in the banana export trade. Rather small (6- to 9-hand) bunches are shipped during the past few years to New York in the "off season", but no plantations are maintained here for the export trade. Most of the 100 to 200 bunches consumed daily in San Juan and Santurce come down by truck from small *fincas* in the interior districts. This variety is seldom cooked here.

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* Allowing for the variations naturally attributable to the effects of soils, droughts, degree of vigor, etc, there are, in the author's opinion, two forms: one short, very sweet, and inclined to show small spots of color on the ripe peel; and a longer, larger, less sweet variety Any or all the names, however, may be applied to either variety here

Gigante Enano; the preposterous name (dwarf giant) of this rather rare but widely known variety requires changing: Guarán Enano would be preferable, but would still leave some confusion with the true *Enano* (*M. Cavendishii*).

A flour has been made at the By-Products Plant, the fruits being dried just before ripening; the taste of Guarán flour, however, is not pleasant to most people and efforts to thus utilize the vast quantities of wasted fruits in other Tropical American countries has practically always resulted in failures—even during the World War, when millions of bunches rotted either on the plantations or on the dump-heads at the shipping ports, while only a few desultory attemps at drying the pulp for export as flour were made. The fecula of this variety, however, is rather gummy and unless dehydrated (as in the drying apparatus at the By-Products Plant) thoroughly is liable to mould.

Manzana, or *Apple;* a very common, second-class old variety grown both for market and home use by the farmers of all districts. Non-variable; some bunches, however, have fruits most of which contain hard lumps of ill-flavored pulp. The very thin delicate peel frequently splits if the bunch is allowed to ripen *in situ*.

Monte Cristy; a very large form of the common Guarán, or Gigante. The fruit is greener and of enormous size. "Johnson" may be another name for this variety; bunches of 20 hands or more are sometimes reported.

GUINEO ENANO, Chinese, or Dwarf, or Canary Banana, *Musa Cavendishii* Lamb.

This very interesting species (of uncertain, but probably South Asian origin) is becoming one of the commonest bananas in Porto Rico. Two advantages it has over the other Musas: it resists the banana disease very well, and it is not so badly damaged by the wind. Its short, rigid leaves on very short petioles, and its sturdy, blackish, very short "stem" are distinctive features; the flower-bud, or *pámpana,* is close to the terminal hand, *i. e.,* there is no bare space on the rachis; the bunch is comparatively heavy, and sometimes tips over the plant unless propped up well. The medium-sized fruit never becomes yellow; the thinnish green peel sometimes splits; the bouquet of the ripe fruits is exquisite. Because of its tendency to separate from the rachis, even before full ripeness, this Banana is not a "good shipper".*

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* In the Australasian countries the hands are cut off, wrapped separately, and packed in crates, thus avoiding the tear in the skin at the base—and immediate inception of decay.

As grown here the enano seldom reaches 2.5 m. in height of pseudo-stem. Nearly twice as many plants may be set on a given area as in the case of the Guarán.

A variety (Doble, or Double) exists in which the "stem" divides into 2 or 4; and each of these may prdouce a double rachis: thus, theoretically (but never in evidence), one bulb might bear any number of bunches up to eight.

GUINEP. See **Quenepa.**

GUINGAMBO, Quimbobó; Okra; *Abelmoschus esculentus* (L.) Moench.

One of the commonest garden vegetables throughout the Island. Three varieties are recognized, only two of which are common. The unripe fruits are used in soups and stews, salads, and with rice; usually sold in small bunches in the markets, practically throughout the year. "Home-grown" seed succeeds well.

GUIRO; Gourd; *Cucurbita lagenaria* L.

Only the half-ripe fruits of this common Cucurbit are (very rarely) used for food. The local variety is much inferior as a food plant to the Upo of the Philippine Islands, whose fruits reach 80–150 cm. in length.

HABA; Lima Bean; *Phaseolus lunatus* L. var. *macrocarpus* Benth.

An old favorite; possibly indigenous; widely cultivated. Several varieties grown for the local markets; a medium-sized white-seeded form the commonest. Bush Limas are being tested. Not so "resistant" as the Bonavist, but more popular.

The Philippine "Patani" variety (of a distinct type) succeeds very well here.

HABA DE SIEVA; Civet or Sieva Bean; *Phaseolus lunatus* L.

This smaller-seeded Lima with pods having a long sharp beak is grown with and confused with the true Limas.

HABICHUELA; Kidney Bean; *Phaseolus vulgaris* L.

One of the commonest major food crops of the Island. Exact place of origin uncertain, but according to Las Casas and Oviedo, the Arawaks and other Indian tribes of the Antilles used one or more bean-like seeds as food.

About 6 varieties are widely cultivated and marketed, some 20 others are in evidence at Government institutions and on private estates. Some sorts appear largely dependent on their special root-nodule bacteria and will not grow well in new fields; others seem to be so well "acclimated" that they grow off well almost anywhere.

The dwarf (var, *nanus* Aschers) or bush, forms are grown on a larger scale (sometimes in fields of several acres extent) than the pole beans.

Several varieties imported in enormous quantities.

HABICHUELA ATERCIOPELADA; Velvet Bean; ***Stizilobium Deeringianum*** **Bort.**

Rather recently introduced from United States and grown partly as a cover, partly as a forage crop. Seeds not eaten here. One of the most rapid-growing forage plants. Seldom made into hay. Attains 20 m.

An "improved" "bush" form is being tried out; 1 m.

HABICHUELA GALANA; Scarlet Runner Bean; *Phaseolus multiflorus* Willd.

This old species, native to Tropical America, is cultivated both as an ornamental and as a food plant. The very large beautiful seeds are not so delicate in flavor as the Lima, and should be used before fully ripening.

HABICHUELA SOYA; Soy Bean; *Soja Max* (L.) Piper.

About 15 varieties of this Oriental grain and forage crop have been distributed by the Federal Experiment Station, Insular Experiment Station, Model Farms and Trujillo Plant Propagation Station; 1–1.5 m. Some varieties are badly attacked by leaf fungi and some yield very poorly. Not yet under cultivation in the citrus plantation .

HABILLA; Wild Yam Bean; *Cacara erosa* (L.) Kuntze.

Fairly common is a semi-wild state. The seeds are not used here.

HAUM; *Amaranthus tricolor* L.

A recently introduced salad plant from the Philippine Islands; 1 m. It is really only a variety of the common species which has been developed into a nearly fiberless spinach-like vegetable.

HERB PATIENCE. See **Espinaca Sin Aroma.**

HEDIONDA; Coffee Senna; *Ditremexa occidentalis* (L.) Britton & Rose.

A cosmopolitan weed, 1–1.5 m. The small (4 mm.) brown seeds are occasionally used like coffee in preparing a hot beverage.

HEDIONDILLA; Wild Tamarind; *Leucæna glauca* (L.) Benth.

Probably indigenous, extremely common shrub in drier districts, 2–6 m. Foliage, much relished by goats, has a mysterious but pronounced depilatory action on horses and swine.

HEVI. See **Jobo de la India.**

HIERBA GATERA; Catnip; *Nepeta Cataria* L.

This temperate tea and seasoning herb does not endure the heat well here, but at Trujillo has grown to 30 cm.

HIGO; Fig; *Ficus Carica* L.

First-class fruit shrub, 2–5 m.; probably introduced long ago, but nowhere successfully cultivated as a crop. Nematode worms presumably weaken the root-system so much that little or no fruit is produced in most cases.

The "Lemon" Fig type may give fair results at Villalba and Sabana Grande Model Farms. A small tree bears well at the Río Piedras Experiment Station.

HINOJO; Fennel; *Fœniculum Fœniculum* (L.) Karsten.

This old European seasoning herb is cultivated for its strong-flavored seeds.

The Florence, or Sweet, Fennel, (var. *dulcis* Alef.) has succeeded very well indeed at both Vega Baja Farm and Trujillo Plant Propagation Station; at both places these plants quickly reach a height of about 1 m. and produce magnificent umbels fully 10 cm. in diameter; the highly aromatic and fragant leaf-bases are not relished here.

HISOPO; Hyssop; *Hyssopus officinalis* L.

A first-class seasoning herb from Europe and Temperate Asia, growing well at the Trujillo Plant Propagation Station.

HOG PLUM. See **Jobo.**

HONDAPARA; *Dillenia indica* L.

A magnificent large Asiatic tree introduced about 1903 at the U. S. Experiment Station. This tree has fruited heavily for many years but it has few descendants in the Island. The fruits attain a diameter of 10–15 cm.

HORSE RADISH. See **Rábano Picante.**

HORTENSIA; *Pereskia grandiflora* Haw.

A shrub or small Brazilian tree, 4–6 m., armed with very long strong spines. Fruit pear-shaped, reddish Cultivated; a fine specimen at Villa León, near Bayamón.

HORTENSIA DE BEJUCO; Barbados Gooseberry; *Pereskia Pereskia* (L.) Karst.

Cultivated occasionally; a slender woody vine, practically spineless, up to 10 m.; fruit reddish-yellow or reddish, 1–2 cm. in diameter; pulp acid. Indigenous.

ICACO; **Cocoa-plum**; *Chrysobalanus Icaco* L.

A third-class fruit-shrub, 1–5 m.; probably indigenous; very common near the coast in waste ground; never cultivated, and seldom marketed. Fruits variable in color, white or pale pinkish, or purplish black. Petals cuneate. Pulp dry, sweet.

Another species (*C. pellocarpus* G. F. W. Meyer) having spatulate petals occurs on hillsides and, according to Britton & Wilson, is "probably a race of" *C. Icaco.*

ILAMA; *Annona diversifolia* Safford.

First-class fruit tree, 5–7 m.; recently introduced; native to Mexico and Guatemala. A lot of seedlings, presented by the U. S. Department of Agriculture, is distributing from the Trujillo Plant Propagation Station. Fruits combine the good qualities of the Guanábana, the Anón and the Corazón. Two forms, a sweet, white-pulped and an acid, pink-pulped, with many sub-forms are known. Probably exportable.

JABOTICABA; Probably *Myrciaria cauliflora* Berg.

Recently introduced first-class fruit tree. At Río Piedras Experiment Station. Brazilian. Four or 5 species are included under this common name; all should be tested here.

JACANA; *Lucuma multiflora* A. DC.

An indigenous large tree, especially common on the south side of the Island; 20–30 m.; fruit ovoid or obovoid, 3–5.5 cm. long, usually one-seeded; amount of edible pulp small but good.

JACINTO; **Nasturtium**; *Tropeolum majus* L.

In the higher localities (especially at Barranquitas) this beautiful plant grows luxuriantly. For flavoring fresh salads there is no better culinary herb; the unripe seeds, the flower buds, and the young leaves are excellent eaten fresh or pickled. Partial shade at sea-level allows the plants to make a larger growth (0.5–1 m.).

JAGUA; **Genipap**; *Genipa americana* L.

Fourth-class fruit tree, 5–15 m.; native throughout Island, never cultivated. Fruit used in making a tonic drink and other similar preparations; its strong unpleasant flavor and odor render it objectionable to most individuals. No variation noted. The fruit is quite commonly sold in the markets.

JAK; *Artocarpus integrifolia* L.

This second-class, East Indian fruit tree (5–10 m.) has been fruiting for several years in various parts of the Island. Probably all the other races (perhaps some 25 or more) would succeed here at sea-level as well as the one now established.

The nearly ripe or ripe seed (beter than that of the Seed Breadfruit) is fairly good boiled or roasted. The pulp, hardly edible raw, when boiled with sugar makes a fair "dulce"; it should be thoroughly ripe—almost fermented.

JAMBOLANA; Java Plum; *Syzygium jambolanum* (Lam.) DC.

Introduced through the U. S. Experiment Station at Mayagüez in 1903. Still extremely rare. Propagating at Trujillo Station.

JENGIBRE; Ginger; *Zingiber Zingiber* (L.) Karst.

This Old-World spice root was early brought to Porto Rico by the Spanish colonists and during the 16th century was an extremely popular crop here—in fact its cultivation at one time so threatened cane culture that an edict had to be issued restricting its cultivation.

Very few fields specifically dedicated to ginger growing are in evidence here although the total acreage of scattered areas runs into hundreds; the total production is probably 50 to 100 tons now as against several (300 to "700") hundred tons around the close of the 16th century.

On account of the expensive labor here now it is impossible to peel the roots as is done in Jamaica, and largely for that reason the Porto Rican article is not known to any great extent on the mainland market. Several tons of roots were dried during the 1923–24 season of the By-Products Plant at Mayagüez and some of this material has been held over for one year partly to determine its keeping quality in sacks.

It appears there is a belief in the New York market that the Porto Rican root contains less oleo-resin, but this matter has not been positively settled.

Authorities differ as to whether the root grows best in sandy or in clay soils. The plant endures partial shade but, especially in the cooler regions, grows well in full sun. There is apparently no variation, however, in the species here. Should a practical method be found therefor and should the mainland market require it, extract of ginger could easily be made here, or even powdered (ground) ginger.

JENGIBRILLO; Turmeric; *Curcuma longa* L.

This East Indian species is naturalized in Porto Rico, occurring in many areas as a persistent weed which is difficult of eradication. The orange-colored rootstocks are of good size and rich in coloring material, but no market has been obtained for them in the mainland thus far. Locally, however, a moderate quantity of the root is used in coloring foods.

JOBO; Hog-Plum, Yellow Mombin; *Spondias Mombin* L.

Native third-class fruit tree, 2–20 m.; probably never actually cultivated, but extremely common (perhaps numerically the most abundant fruit tree in the Island) in all districts; planted (stake cuttings) as fence posts. Variable, but fruits always yellow, with comparatively little pulp; relished by animals. Probably the principal host plant of the West Indian Fruit Fly (*Anastrepha fraterculus.*)

JOBO DE LA INDIA; Hevi; *Spondias dulcis* Frost.

Introduced second-class fruit tree, 5–20 m.; fairly common in cultivation. Quite variable; probably easily improvable. Brought to Jamaica with the Pana from Tahiti in 1793. Select varieties may be propagated in the same manner as the Aguacate: cuttings do not root well.

JOBILLO, Ciruela Amarilla; *Spondias cirouella* (Bello) Tussac.

This variety, much more rare than the common Ciruela, occurs on west end of the Island. The tree closely resembles the Ciruela but the fruit never has the purple or reddish shades. The pulp seems to be somewhat sweeter and the fruit is rather larger.

JOB'S TEARS. See **Camándulas.**

JOHNSON GRASS. See **Yerba de Johnson.**

JUJUBA; Jujube; *Zizyphus mauritiana* Lam.

This Oriental species has been introduced through the Insular Experiment Station. It is apparently succeeding.

JUJUBA; Jujube; *Zizyphus jujuba* L.

Recently introduced second-class fruit tree, 5–9 m.; at Río Piedras Experiment Station. Will probably succeed at San Sebastián, Cayey and Utuado Model Farms.

JUJUBE. See **Jujuba.**

JUNQUILLO; Beggarweed; *Meibomia purpurea* (Mill.) Vail.

This exceedingly common old Tropical American weed has been cultivated here since 1900, partly as forage but largely as a nitrogen-gatherer; at Palo Seco plants have reached a height of 3 m.—twice the normal size.

KAFIR. See **Millo.**

KALE. See **Berza.**

KALE, CATTLE. See **Berza de Ganado.**

KAKI; Japanese Persimon, Kaki; *Diospyros Kaki* L.

Introduced by the Mayagüez Experiment Station in 1903, this first-class fruit tree has not well withstood the climate; a few small trees are in evidence at Trujillo.

KALPI; *Citrus webberi* P. J. Wester.

One of the 25 or more interesting citrus fruits endemic in the Philippine Islands; 5–10 m.; introduced (seed) in February 1925 from the Philippine Bureau of Agriculture; propagating at Trujillo Plant Propagation Station.

A "very variable species", according to the discoverer and author P. J. Wester, Agricultural Advisor to the Philippine Government; some forms have juicy, acid fruits up to 10 cm. or more in diameter. A promising stock.

KARANDA; *Arduina Carandas* (L.) Britton.

A recently introduced second-class fruit shrub, 2–4 m., of East Indian origin. Seeds presented by Bureau of Agriculture of Philippine Islands; now distributing from Plant Propagation Station, Trujillo The black, oblong, red-pulped fruits for jellies, sauces, etc.

KEMILI; * *Coleus rotundifolius* Chev. & P.

Tubers of this very interesting and potentially important new crop were received in 1925 at the Trujillo Plant Propagation Station from the College of Agriculture, Los Baños, Luzón, P. I.; native of French West Africa; 0.5 to 1 m.; three or four distinct races of two or three species are grown for food by certain tribes in the Western Sudan. The name Kemili is applied to this species in Sumatra and it has been adopted by Mr. P. J. Wester in his "Food Plants of the Philippines".

The irregular-shaped tubers, much smaller than those of the Girasole, are quite sweet and somewhat aromatic; according to Wester it is reported to yield from 30 to over 40 tons of tubers per hectare.

Easily propagated from cuttings.

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* In 1907 the discoverer of this species, M Chevalier, presented a collection of West African edible Coleus tubers for test by the U S Department of Agriculture, these were probably the first specimens to reach the Western Hemisphere and were carefully grown in large pots in the Department's greenhouses where they succeeded so well that the tubers overflowed their containers

KETEMBILLA; *Dovyalis hebecarpa* Warb.

A shrub or small tree from Ceylon, recently introduced from the Philippine Islands (Bureau of Agriculture). First-class fruit, acid, purplish, 2–2.5 cm. in diameter; suitable for jellies and sauces. Distributing from Plant Propagation Station at Trujillo.

KIKUYU GRASS. See **Yerba Kikuyu.**

KOHLRABI. See **Colinabo.**

KOKAM; **Kokam Butter**; *Garcinia indica* Choisy.

A specimen of this splendid fruit tree is in evidence at the U. S. Experiment Station. The fruit resembles the Mangosteen but is more acid as to pulp, with more numerous seeds; these seeds are the source in India of an edible fat called Kokam Butter.

KOLA. See **Cola.**

KUDZU; **Kudzu Vine**; *Pueraria hirsuta* Schneid.

This Japanese forage vine has never given satisfactory results here, although its perennial rootstocks are an important factor in its favor. The velvet bean is far more popular.

KUMQUAT LARGO; **Oblong Kumquat**; *Fortunella margarita* (Lour.) Swingle.

Nowhere planted commercially, but fairly common among the citrus groves of the Island. Relished by many as a dessert fruit, and frequently preserved (as jam, marmalade, etc.) the exquisite, distinctive flavor of the peel, as well as its bright color, and the attractive shape of the (whole, halved or sliced) fruits place this species in a class by itself.

Three or four hybrids have been made by the citrus specialists of the Bureau of Plant Industry of the U. S. Department of Agriculture:

Limequat, with the lime
Orangequat, with the orange.
Citrangequat, with the citrange.

Not only are the blended flavors of these hybrid fruits of dietetic interest, but the hybrid character of root, leaf, and branch may show advantages from the cultural point of view.

KUMQUAT REDONDO; **Round Kumquat, Marumi**; *Fortunella japonica* (Thunb.) Swingle.

A much less common species than the oblong but occasionally found in citrus orchards here.

The newly introduced (at the Plant Propagation Station at Trujillo) *Meiwa* may, perhaps, be included under this species.

LACUCHA; Lakoocha; *Artocarpus lakoocha* Roxb.

This excellent Oriental fruit tree was introduced in 1921 at the U. S. Experiment Station; 10–15 m. The fruit, resembling a small irregular-shaped breadfruit, has a rich creamy pulp which is eaten without cooking. Very rare in the Western Hemisphere, but has fruited in Trinidad for many years.

LAKOOCHA. See **Lacucha.**

LANGSAT. See **Lanzón.**

LANZON; Langsat; *Lansium domesticum* Jacq.

Very recently introduced and rare, first-class fruit tree, 5–8 m.; growing well at Río Piedras Experiment Station. Distributing from Trujillo Plant Propagation Station. An excellent Philippine fruit, occurring in several varieties.

LEAF-BEET. See **Acelga.**

LECHESILLO. See **Caimitillo.**

LECHOSA, Papaya; Papaw; *Carica papaya* L.

This very old cultivated tree of unknown original habitat has long been a common plant in all parts of the Island; 3–6 m. Escaped from cultivation in waste grounds in the lower elevations. Practically always diœcious although male trees sometimes bear small fruits.

Both the young and the ripe fruits are used, the former frequently made into a dulce with syrup. The ripe fruits are a popular breakfast or dessert fruit. The base of the trunk of young vigorous plants is also used, grated and boiled with sugar and flavoring.

The papain gum is not collected from the green fruits here. The red-fleshed varieties, common in the Philippines and the Canal Zone, are extremely rare here. While some fruits may reach a weight of 2 kilos the average size is about 1 kilo.

LECHUGA; Lettuce; *Lactuca sativa* L.

One of the commonest of the "temperate" vegetables; grown mostly during the rainy season and winter months. Many varieties, mostly of the head type (*L. sativa* var. *capitata* L.) are grown; the Cos, or Romaine (*L. sativa* var. *longifolia* Lam.) also does well in certain conditions. History unknown.

LEEK. See **Puerro.**

LEMON. See **Limón.**

LEMONIME; *Citrus aurantifolia* X *C. Limonum.*

Specimens of this interesting new hybrid were received December, 1924, from the U. S. Department of Agriculture and are now growing at Trujillo Plant Propagation Station. The "Mexican" Lime was the male parent.

LEREN; Sweet Corn Root; *Calathea Allouia* (Aubl.) Tindl.

Probably one of the principal food plants of the aborigines; on account of its inability to produce seed now it has obviously been under cultivation for thousands of years. Apparently indigenous throughout all the larger West Indian Islands and presumably in considerable areas in northern and central South America; yet it is doubtful whether it was ever in use by any of the prehistoric races of the mainland. It is one of the few primitive American crops showing today no tendency to variation in any part of the its wide range of habitat.

Unfortunately, this old crop requires a very long time,—not less than 15 months and usually about 18 months for maturing the tubers.

These tubers are almost unique in having a semi-transparent area in the center, although the texture and flavor of the entire fecula seems to be about the same. When well grown in loose moist soils these "eye"-less tubers are of a fairly regular oval shape from 2–5 cm. in length; the thin yellowish cuticle covering the snow-white star hy fecula is roughened by the points of attachment of the numerous fine roots which supply part of the nutriment to the tuber. The slender stem which attaches the tubers to the central rootstock is 5–10 cm. or more long. Propagated only by division of the *"cepa"*, or cluster of rootstock bases.

Especially while cooking and while hot these tubers give off a pronounced odor of sweet corn and, if eaten when freshly cooked, they also have the taste. In 1903 they were introduced into the State of Florida and distributed from one of the largest nurseries there under the name of "Sweet Corn Root".

Most markets of the Island sell this interesting root crop from about December to May. The price is comparatively high but they are a favorite ingredient in stews, soups, etc.; also good cooked as a separate dish and eaten with butter or a milk gravy.

LENTEJAS, Lentils; *Ervum Lens* **L.**

Very rarely grown, never as a crop, but occasionally fruits fairly well. Very old legume, from S. Europe.

LENTILS. See **Lentejas.**

LETTUCE. See **Lechuga.**

LIBATO; *Basella rubra* L.

A very luxuriant, almost fiberless trailing vine, native of Tropical Asia, introduced several years ago as a salad plant. Two or three varieties, one green and one with purplish leaves are in evidence; 2-4 m. or more. These so-called "spinach" plants endure full sunshine in the rainy season but are perhaps better grown in partial shade. Their principal fault is their lack of distinctive flavor.

LIME. See **Limón Agrio.**

LIME-BERRY. See **Chinita.**

LIME, SWEET. See **Chinita.**

LIME, SWEET. See **Limón Dulce.**

LIMEQUAT; *Citrus aurantifolia* X *Fortunella japonica.*

Two varieties, the *Eustis* and a seedling of this interesting hybrid, were received in December, 1924, from the U. S. Department of Agriculture.

The *Eustis* hybrid was made between the Mexican Lime and the Marumi Kumquat. The seedlings may or may not "come true" to half-and-half type; the chances are that they will show considerable variations.

LIMON; **Lemon;** *Citrus Limonium* Risso.

Rather rare in fruit orchards, but usually very prolific and fairly vigorous, 2-4 m.; Asiatic in origin. Practically no local demand and, without expensive curing processes, hardly saleable in competition with the bright, "cured", imported fruit.

The *Sicily* and *Villa Franca* seem to be much the most common varieties; the very large *Ponderosa* is not marketed. Some few trees, apparently seedlings, practically worthless, have been found in out-of-the-way places. The export crop of *Sicily* lemons varies from 1,000 to 2,000 boxes per year.

A splendid variety of citrus fruit known as "California Dwarf Lemon" and presumably originating in China (collected near Pekin by Mr. Frank N. Myer about 1908) has been in evidence at the Insular Experiment Station since 1922; this tree is spineless, the leaves resembling the Limón de Cabro, round, smooth thin-skinned fruits about the size of a small orange but with a lemon flavor; this variety is now being propagated for wide distribution throughout the Island.

LIMON BOBO. See **Limón de Cabro.**

LIMON AGRIO; Lime; *Citrus aurantifolia* (Christm.) Swg

Very common everywhere, but never cultivated in orchard form, 2–5 m.; of Asiatic origin. Comparatively little variation in the native variety. Commonly marketed but seldom exported; probably 75 per cent of the crop is not used. Nowhere sufficiently abundant to warrant attempts to utilize the juice; some citrate of lime was produced in 1923 at the Mayagüez By-Products Plant from local fruits.

The fine large *Tahiti*, the *Rangpur*, and a few other varieties have been introduced (about 1903); other varieties should be tested.

LIMON DE CABRO, Limón Bobo; Rough Lemon; *Citrus* hybrid

Probably an old natural hybrid (or cultigen) between the true large Lemon (*C. Limonium*) and some fruit like the citron, or some pomelo; distinct from, but close to, several of the rare Philippine fruits, some of which are apparently natural hybrids (existing when discovered, in 1912–15, as only a few individual trees growing in small isolated areas).

A widespread but rather uncommon old fruit, semi-cultivated, 2–5 m.; famous as a stock for orange, grapefruit, etc. Rarely used as a fruit; the peel is sometimes preserved as a dulce or even candied. Slightly variable, but grows true from seed. Excellent root system for shallow soils, and a fairly rapid stock.

LIMON DULCE; Sweet Lime; *Citrus limetta* Risso

Never common, but widespread, rather popular, very thorny shrub or small tree, 2–6 m. Somewhat variable; probably two or three forms recognizable here.

Has no particular interest or value; a tree, however, should always be in evidence on every farm and in all fruit collections

LIMONCITO. See **Chinita.**

LITCHI; Leechee; *Litchi chinensis* Sonn.

A first-class Chinese fruit tree recently introduced; 8–15 m.; fruit bright red, 2–4 cm. in diameter, the rind covered with prominent fleshy tubercles encloses a very juicy white pulp and a moderately large seed.

Three specimens about 4 years old are in evidence in the collection of Mr. Harold I. Sewall, Naguabo.

LOCUST, WEST INDIAN. See **Algarrobo.**

LONGAN; *Euphoria Longana* Lour.

This second-class Indian fruit tree has been introduced at the U. S. Experiment Station; 5–10 m., but fruiting frequently at much smaller size. While closely related to the delicious Litchi the fruit is usually too sour to please most people. The fruit and plant are quite variable.

LOQUAT; *Eriobotrya japonica* Ldl.

Second-class introduced (from Asia) fruit tree, 3–6 m.; has fruited for years at the Federal Agricultural Experiment Station at Mayagüez; growing at Río Piedras. Variable; named varieties in Japan; would probably succeed better above 500 m. elevation.

LUFFA. See **Esponja.**

LLAGRUMO; **Trumpet-wood**; *Cecropia peltata* L.

An indigenous forest tree, 10–20 m. The fleshy mulberry-like elongate fruits (5–6 cm. long) are quite edible, but not used here. A variety ("*C. palmata* Wild."), introduced about 1910 into the Philippine Islands and listed by Wester as "Yaruma" has fruits 15–25 cm. long and 1.8 cm. in diameter.

The leaves are an excellent forage, fresh or dried.

MABI; *Colubrina reclinata* (L'Her) Brogn.

This native tree attains a height of 20 m. The bark is a material of considerable importance, used in the preparation of a very popular drink; a decoction of the bark added to sweetened water is allowed to ferment overnight and thus develop considerable effervescence. An imported variety (from Jamaica?) is considered superior to the native and is sold in the drug stores.

MADROÑO; *Rheedia madruno* (H. B K.) Tr & Pl.

First-class fruit tree, 5–10 m., recently introduced (through the U. S Department of Agriculture, Washington, D. C.) from Central America. Of the same family as the Mangosteen, this species is a valued acquisition, and is growing well.

MAIZ: **Maize. Indian Corn**; *Zea Mays* L

Several thousand acres of Flint Maize are grown, mostly in the southwestern districts; plantings are made in April and May or in August and September, usually. Very litle Dent and no Flour Maize grown. Some meal is imported for human food and for stock feed; small mills (particularly at Mayagüez) and hand stones provide a fair (usually coarse) product. The consumption of meal is probably increasing but it should constitute a much larger proportion of the "small farmers'" diet; as proved in one of the hottest countries (Java), maize is not especially "heating"; when parched, dehulled, and finely ground (as in Nicaragua; *pinol* and *pinolillo*) and taken as a (thin gruel) beverage, or made into *tortillas* as in Mexico, there is no crop that could take the place of Maize in the interior districts as a cheap rich food; these ways of using the grain are not yet in evidence here. Immature ears are often marketed.

MAIZ DULCE; Sweet Corn; *Zea Mays* L. var. *rugosa* Bonaf.

One of the most difficult temperate crops to grow near sea-level in the Tropics of either Hemisphere. In the higher elevations some varieties can probably be grown with care. A hybrid (presented by the St. Croix Agricultural Experiment Station in 1924) between "Mexican June" and a local variety is being tried out with little hope of success.

MAIZE. See **Maiz.**

MALAGUETA, Guayavita, Ausu; Wild Cinnamon, Bay; *Amomis caryophyllata* (Jacq.) Krug. & Urban.

An indigenous tree fairly common in the forests and on hillsides, both in moist and dry districts; 10–15 m. This tree is seldom actually cultivated in groves but is frequently semi-cultivated especially in the south western part of the Island. Here the leaves are not used to any great extent for seasoning purposes; neither are the fruits used, as they really might be, as a spice. Many tons of oil are manufactured annually, principally in Cabo Rojo, Ponce and Guayama; crude stills are used; much of the oil is wasted and no attempt at rectification is made.

MALANGA; Taro; *Caladium Colocasia* (L.) W. F. Wight.*

This very old root-crop probably originated in India, thence spreading eastward through Polynesia—where it exists today under some 50, or possibly 75, forms. It probably reached the West Indies late in the 16th century.

No large fields of Malanga are in evidence here; it is usually planted along stream margins and in wet soil in the hills. The rhizome, usually weighing 3 to 6 (or occasionally 10) kilos when mature, is perhaps the cheapest food sold in the markets.

The extreme fineness of the texture, the smallness of the starch grains (about 1/10 the size of those of the Yautía), and the large amount of "gummy" substance in the fecula prevent using this

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*Formerly known as *Colocasia antiquorum* Schott var. *esculenta* (L.) Schott.

cheap root as a source of starch: the emulsion of the grated root in water ferments before the light starch grains can settle.

The peeled and dried rootstock makes an excellent meal, of value as an invalid food ("Taroena"). The rarity here of even small plantings of this very cheap food crop is hard to explain.

MALAY APPLE. See **Ohia.**

MALOJILLO, Yerba Pará; Pará Grass; *Panicum barbinode* Trin.

This South American grass has long been widely cultivated as one of the two commonest forages of the American Tropics; succeeds better in wet fields, but will endure almost any soil if drought does not interfere. Propagated by stem cuttings; the short pieces of the orts from stables, taken out with the manure, frequently sprout in crop fields, the species thus becoming a weed. Not regularly pastured; the cut fodder is sold in "manojos", or bundles. At the By-Products Plant at Mayagüez, a meal, which keeps indefinitely in sacks, can readily be prepared (by cutting, drying, and grinding) from the fresh forage

MAMEY; Santo Domingan Apricot; *Mammea americana* L.

This handsome old native species occurs throughout the Island, especially in semi-abandoned fence-rows and on hill slopes; 5–20 m. Absolutely non-variable. The pulp is occasionally consumed raw put is usually made into a paste, conserve, or dulce. The seeds are not used. The leaves are frequently used to form protective cylinders to guard young plants, such as tobacco, against the attacks of the changa; most trees in the vicinity of tobacco fields are anually stripped of their leaves and small branches for this purposes. Probably of real importance to the Arawaks.

MAMEY SAPOTE; Marmalade Plum; *Achras Zapota* L.

(This species has heretofore been known in pomology as *Lucuma mammosa* [L] DC.).

Probably indigenous first-class fruit tree, 10–20 m. Remarkably rare in Porto Rico at present: probably less than 25 mature trees exist in the whole Island. Apparently not variable, and Porto Rican fruits appear to be identical with those of Panamá and México. Dessert fruit which requires, in the minds of many, some special treatment to render it entirely agreeable, probably on account of a mawkish, strong flavor and not very pleasant odor.

MAMEYUELO. See **Sapote de Costa.**

MANDARINA; Mandarin, Tangerine; *Citrus nobilis* Lour.

Sparingly cultivated throughout the Island; probably introduced by the Spaniards. Only one variety, *King,* has been extensively planted here. The following varieties (*C. n.* var. *deliciosa* Swg.) are found among the citrus groves on the north side of the Island; others should be tested; at least 6 good varieties occur in Trinidad and the Windward Islands; in the Orient there are many.

> *King.* This very (and justly) famous variety stands in a class by itself; it is 2 to 4 times the size of the regular Mandarin. Here its color never becomes high enough to command a fair price—unless allowed to fully mature (when it is likely to rot). Reported to have originated in one of the royal groves in Siam. Extensively planted in 1901, but the trees were soon afterward cut back and rebudded. Becoming popular locally.

The following hybrids of this excellent species have been produced by the U S. Department of Agriculture and, it is hoped, all can soon be tried out here:

Satsumelo (with the Grapefruit)
Oranguma (with the Orange)
Citrunshu (with the *Poncirus trifoliata* Raf)
Citrandarin (with the *P trifoliata*)
Citranguma (with the *Citrange*)
Citrangarin (with the *Citrange*)
Siamelo (with the *C. Grandis* (L.) Osbeck)
Siamor (with the *C sinensis* (L.) Osbeck) and the Tangelo (q. v.)

MANDARINA SATSUMA; Satsuma Orange; *Citrus nobilis* var. *Unshiu* Swingle.

This sub-species, which has succeeded so well along the Gulf Coast of Southern States, has not been well represented here. In January, 1925, about twenty-five 2-years-old plants of the *Owari* variety were set in the nurseries of the Trujillo Plant Propagation Station. None of the many other Oriental varieties seem to have been introduced.

MANDARIN. See **Mandarina.**

MANGO; Mango; *Mangifera indica* L.

From some points of view this old Indian tree is today the principal fruit tree of Porto Rico, since it reaches more people and is of greater importance in the way of food for the masses than any other species. According to Dr. A. Stahl* the mango was introduced in 1740 by Mr. Fitzpatrick, grandfather of don Santiago McCormick.

However, the crop period is comparatively short—June to October; and the great majority of the trees bear only very inferior types of fruit. Almost every tree, outside of the Federal Agricultural Experiment Station collection (some 500 specimens), the smaller groves of the various Insular Government's properties, and those grafted trees on a few private estates, is a seedling; and, while certain types here do reproduce fairly true from seed the general run of trees indicate a tendency to vary, and hence there are hundreds of slightly distinct *forms* although the number of native types is perhaps less than 10.

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* A manuscript note in "Estudio sobre la Flora de Puerto Rico", 1888.

Theoretically, all the old native sorts are polyembryonic: *i. e.*, each seed germ divides into 2 to 25 or more and under favorable conditions each of these plantlets may grow into a tree almost exactly like its parent; but there are still some factors in polyembryony that are not well understood, and the whole subject of mango variation requires much more study.

The seedling races of mangos in Tropical America are much better known and, of course, much fewer than those of the Orient, while those of Madagascar and the East African coastal area are very imperfectly worked up. The chief types of Porto Rican mangos are as follows.

Blanco; an extremely common prolific race.
Largo; a small, very fibrous variety.
Mangotina; a small or medium-sized fruit, common on the south side.
Piña; really a group name applied to several second-class varieties from all districts of the Island.
Redondo; a roundish, good-sized fruit.
Other country names are *Toro:* one of the commonest native sorts; *Rosa, Pazote, Masa, Manila, Hebra.*

The above varieties are all large, dense-headed forms, usually beginning to bear at three or four years of age (4–6 m.) and reaching a height of 15–20 m. Heavy crops of fruits are usually borne every two years. Rains on the north side of the Island seem to interfere with the setting of the fruit, though this affects the grafted varieties more than the natives.

Since the Mango grows so rapidly even in exposed sites on hillsides it is frequently planted as a wind-belt. It is also used for charcoal; and the leaves can be fed to cattle (as in Vieques) in time of drought. A pig and cattle feed has been made at the Mayagüez By-Products Plant from green mangos and also from the seed kernels of ripe fruits. The sugar content of the ripe fruit pulp varies from about 10 per cent to nearly 16 per cent; the acid content varies from one-fourth to one-half of one per cent. A diet composed almost entirely of mangos appears to be quite safe for a good number of days, and during mid-season in some of the interior districts whole families subsist largely on these fruits. Domesticated animals also can live on mangos.

The introduction of budded India varieties from the Orient began about 1903, through the Experiment Station at Mayagüez. Some of these varieties came from Florida, others directly from the U. S. Department of Agriculture at Washington, D. C. Various introductions have been made by private parties, especially in the Island of Vieques, and there are probably today a considerable number of grafted trees, the names of which have been forgotten or lost.

The presence of the West Indian Fruit Fly (*Anastrepha fraterculus* Wied.) militates against the export of Porto Rican mangos, although comparatively few fruits here are attacked by the fly and then only when ripe—usually when lying on the ground rotting. No large orchards of grafted mangos are at present in evidence here and it is not likely that any will be established in the near future. Many of the introduced grafted varieties are severely attacked when in flower on the north side of the Island, by the common Mango Blight (*Colletotrichum gloeosporioides* Hume) and this fungus is so severe in most districts on the north side that few or no fruits set although the trees may be apparently in full vigor.

The following varieties of grafted mangos have been introduced from the U. S. Department of Agriculture, from the Botanic Gardens of Trini ad, Martinique, Guadaloupe, and Jamaica, and are now established here:

Alphonse, or ***Hafu;*** one of the West Indian varieties, a good producer of fiber-free fruits.

Ameeri, or ***Amiri***; a large sour fruit with little fiber.

Amini; a smallish yellow, high-flavored nearly fiberless sort from Bangalore, India. One of the best, since it bears regularly here.

Arbuthnot; a small, very sweet and juicy yellow or greenish fruit with a firm, dark, yellow flesh.

Bennett; or ***Douglas Bennett's Alphonse;*** one of the best of the West Indian Afoos, or Alphonse, type.

Bhadauria, Bhaduria; a small, poorly colored fruit with a fibrous, subacid pulp.

Bombay Green; a smallish, green-skinned variety, very sweet, fiberless.

Bombay Yellow; a small or medium-sized, yellow or red-tinged fruit, with very juicy and sweet pulp of excellent flavor.

Borsha; a rare medium-sized variety, green-skinned (or red-tinged), of good quality.

Brindabani; small, green or yellowish, with very juicy, highly aromatic pulp with excessive amount of fibers.

Bulbulchasm; small roundish, greenish, variety with juicy and spicy but very fibrous pulp; the Porto Rican trees under this name have either varied *greatly* from the old Saharunpur type or else *are mis-named;* here the fruits are borne large, nearly fibrous and of a peculiar bronze or purplish red color.

Cambodiana; this medium to large regular-shaped, popular variety is precocious, prolific and vigorous; the fruits in Hawaii are resistant to the Mediterranean Fruit Fly but here it is one of the most susceptible to the attacks of the West Indian Fruit Fly. Introduced in 1902 (as a seed) from Saigon by the U. S. Department of Agriculture and sent to the Experiment Station at Mayagüez about 1907.

Carabao: the justly very famous Philippine variety, fiberless, large and of extra fine flavor; comes true to seed

Chempadan: a very rare Indian variety.

Climoise; one of the many strong-flavored varieties from the French West Indies.

Costa Rican; sent to the Federal Agricultural Experiment Station as the "common fiberless" variety from some locality in Costa Rica, C A.

Curaçao; a very inferior variety from Curaçao.

Davy's Favorite; medium to large oval fruit; pulp dry, subacid with little fiber.

Divine; an inferior variety from Guadaloupe (or Martinique).

Enuria, or *Ennurea;* large, long with juicy, firm, well flavored pulp.

Faizan; medium, green to yellow, with good, flavor and small seed.

Fajri, long; a long, large-sized fruit; skin uneven, green, tinged with yellow and red; pulp sweet, nearly fiberless.

Fernández; this old Bombay variety fruits well in the "Jardín de la Convalescencia," at Río Piedras; a medium-sized or large fruit, late in season, of excellent flavor.

Gola; a large, old Saharunpur variety; pulp sweet, juicy, well flavored, nearly fiberless.

Gopalbhog (seedling); small, roundish, old variety with very sweet aromatic flesh.

Gordon, or General Gordon; a splendid fruit of uncertain origin (but probably introduced here from Jamaica) which is bearing very well in the "Convalescencia" garden; green to orange or even reddish; fiber medium, very prolific; unfortunately monoembryonic.

Haden; a seedling of the Mulgoba originating (1910) at Coconut Grove, Fla.; one of the best large mangos (450–550 g.).

Hafu; this is one of the Alphonse, or Afoos, type from India.

Itamaracá; the strange "tomato-shaped" mango of Brazilian origin; color poor, but flesh very spicy and aromatic and nearly free from fiber; very late.

Jamshedi; very similar to if not identical with the Mullgoa.

Julie; an excellent West Indian variety presented (in November, 1924) by the Trinidad Department of Agriculture; probably best flavored of all the West Indians.

Kachmahua; a smallish Saharunpur fruit with good color and an excellent but fibrous pulp. A seedling of this variety has been noted, according to P. J. Wester*, as having a raspberry flavored pulp.

Kissenbhog; (seedling); the true Barbhanga fruit is large, roundish, with a "rosy-pink", sweet, fiberless, pulp of good flavor.

Kistapal; a small, yellow to reddish fruit; pulp, sweet, juicy, with little fiber.

Langra, lage; a medium-sized, roundish old variety of poor color, but good flavor, very sweet but somewhat fibrous.

Madrás; an old Saharunpur variety of medium size; skin brownish yellow to reddish green; pulp fair, fiber little.

Malda; a name which may apply to several varieties originating in or near that famous city of India; one variety (Kumrajali) is said to attain a weight of 2,700 grams, the largest mango and perhaps the world's largest single-seeded, dicotyledonous fruit; some have the flavor of cantaloupes, some the fragance of roses, some are blue, some red; all should be brought in here.

Muller; a rare variety from Amritsar, India.

Martin; one of the high-flavored Martinique varieties.

Martinique; a short-oblong, flattened fruit of poor quality.

Mekongensis; a rare mango presumably from Burmah.

Mulgoba; this was the first grafted variety to be introduced (1899) from Poona, India, into Florida; a smallish, but very beautiful, fair-flavored fruit; very popular.

Mullgoa; a variety of uncertain origin; large, acid, aromatic, with a trace of turpentine and fiber.

Nahababadi (seedling); a small greenish or reddish yellow variety; pulp sub-acid; juicy, fibrous.

Nucka; medium-sized brownish or yellowish; pulp aromatic; juicy, fibrous.

Paheri, Pairi, Pirie; medium or large; golden yellow marbled with green, garnet red on sun-exposed side, with a bluish white bloom; pulp aromatic, sweet, rich.

Pere Louis; a small West Indian mango; roundish, or kidney-shaped; pulp sweet, juicy, fibers fine. Presented (November, 1924) by the Trinidad Department of Agriculture.

Peter's No. 1, Peters; a medium-sized fruit of uncertain origin, beautiful appearance, fair flavor and no fiber.

"A Descriptive List of Mango Varieties in India", by P. J. Wester

Pico (seedling); an excellent variety from the Philippine Islands, long, fairly large, fiberless, sweet.

Reine Amalie; one of the French West Indian varieties.

Sandersha; the largest mango in Porto Rico; fruits from a mature tree at Villa León, near Bayamón, sometimes reach a length of 20–25 cm. and weigh up to nearly 1.5 k.; nearly fiberless, pulp sour except near the skin; color yellow or greenish.

Sanduria (seedling); a small, roundish variety with smooth yellowish or reddish skin; pulp dry, very sweet; good flavor.

Sans Pareille; an inferior variety introduced from Martinique; size medium; color yellowish bronze; flavor too strong, sweet; fiberless.

Savoy; a Martinique variety of unknown merit.

Singapur, Singapuri; an old Saharunpur variety, large, green-and-orange skin; pulp sweet, somewhat aromatic, in flavor resembling the Loquat.

Sufaida; a very large fruit which has given excellent results in Porto Rico; color fair; flavor good; seed small, skin too thin, sometimes splitting (like that of the Sandersha), covered with a thick whitish "bloom".

Sunahra (seedling); small or medium-sized variety; color fair; pulp very sweet, rather fibrous.

Surkha; medium large variety from Saharunpur; yellow to reddish; flesh yellow, juicy, of good spicy flavor, fibrous.

Totapari, or *Totafari;* introduced from Bombay in 1902 by the Experiment Station at Mayagüez and sent hither in 1907.

Some efforts have been made toward canning some of the semi-cultivated fruits here, but it appears that the mango pulp oxidizes readily and the flavor changes rapidly even after thorough sterilization in the can. Dried mango pulp has been prepared at the By-Products Plant at Mayagüez. A preparation of mango pulp with sugar is sold as "pasta de mangó" but this is of small commercial importance; some of this material is occasionally exported to the mainland.

MANGOSTAN; MANGOSTEEN; *Garcinia Mangostana* L.*

This, the best fruit in the world, was introduced by the author in 1903 at the Federal Agricultural Experiment Station, from the Botanic Gardens, Trinidad, B. W. I. From the original lot of seeds 2 plants have survived and for several years have been producing fairly good crops at the said Station. Five seedlings have been introduced through the Trujillo Plant Propagation Station from the Dominica Botanic Gardens during the past 2 years and these are growing as rapidly as could be expected. Seedlings are also being propagated at the Federal Agricultural Experiment Station. The two old trees are now over 5 m.—above the regular height of the trees in evidence in the Mangosteen orchards of Malaya.

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* In Dapitan, Mintanao, the author found in 1911 trees over 10 m in height —probably the largest in the world

MANI; Peanut; *Arachis hypogæa* L.

Widely cultivated in the drier districts, but nowhere on a large scale. Probably Brazilian. Prefers light, sandy soil The Spanish variety is the only one grown to any extent; two or three other varieties are doing very well both at Vega Baja Farm and Trujillo Plant Propagation Station. Deserves extended trial; varieties resistant to fungus diseases may be found.

MANTECA DE SHEA; Shea Butter; *Pentadesma butyracea* Don.

Recently introduced (presented by the Dominica Botanic Gardens) by the Department; distributing from Trujillo Plant Propagation Station. Splendid tree, 10–20 m. West African. Large seeds contain edible solid fat, exported in vast amounts to Europe.

MANZANA; Apple; *Malus Malus* (L.) Britton.

This fruit has been repeatedly tried in various parts of the Island; the want of a resting period, it appears, gradually weakens the trees till pests or physiological troubles cause death. *Red Astrachan* and *Early Harvest* fruited first in 1906 at the Federal Agricultural Experiment Station.

MARACA; Edible Canna; *Canna edulis* Ker.

This magnificent species is indigenous to the West Indies and South America and was probably cultivated here by the Arawaks. 2–3 m.

Fifteen tons of rootstocks per acre are obtainable in good moist soil. No variations have been observed.

The starch grain is one of the largest known (about 30 times larger than that of the yautía), and largely for that reason Maraca starch cannot be used for laundry purposes; the grains, however, are most easily removed from the fecula. The fibers in the roots prevent their use on the table. Not widely cultivated at present.

MARANTA. See **Yuquilla.**

MARAÑON. See **Pajuil.**

MARICAO; *Byrsonima spicata* (Cav.) DC.

An indigenous forest tree, 10–25 m. The small (9–11 mm.) fruits quite edible. Related to cerezas. "Occasionally planted in Porto Rico", according to Britton & Wilson.

MARANGUEY; *Zamia latifoliata* Preneloup.

An extremely common Cycad occurring in the northern limestone hills, abundant in the Vega Baja and Manatí districts. The stems are frequently partially hidden in holes in the limestone rock; a lever, especially in rainy weather, can readily remove the roots. When the scaly rind is removed and the smooth fibrous interior is grated, a very white starch is obtained,—which may be used for either eating or laundry work The juice from the grated root is extremely poisonous, and the starch must be thoroughly washed before cooking for the table.

MARANGUEY DE GUANICA; *Zamia portoricensis* Urb.

This species is confined to the dry southwest portion of the Island. The starch from its roots is undoubtedly just as safe for human consumption as that of the other species but on account of its leaves being supposed to cause a strange disease of animals known as "ranilla" it is not used at present for human food.

MARANGUEY DEL INTERIOR; *Zamia media* Jacq.

This species is much less common than the ordinary plant of the limestone hills of the central northern coast district; it can be, however, and probably is at times used instead of the common species as a source of edible starch.

MARJORAM. See **Mejorana.**

MARJORAM. See **Orégano.**

MATA-GALLINA. See **Yerba Mora.**

MATE; **Paraguay Tea**; *Ilex paraguaiensis* St. Hil.

Recently introduced (through the U. S. Department of Agriculture) shrub, 2–5 m. Distributing from Plant Propagation Station. Will probably succeed at Cayey and San Sebastián. The leaves here appear to contain a normal amount of thein.

MATO DE PLAYA; **Bay-Bean**; *Canavali maritima* (Aubl.) Thou.

A wild species common on or near the sea-shore. A meal, rich in protein and probably safe as a feed for goats and cattle, has been made by drying and grinding this plant (green pods and leaves) at the Mayagüez By-Products Plant.

MATRACA; *Crotalaria* spp.

The following species have been tried out at the Plant Propagation Station at Trujillo, at Model Farms, at the Insular Experiment Station and the Federal Agricultural Experiment Station.

C. incana L. (practically cosmopolitan);
C. retusa L. (indigenous species);
C. juncea L. (from the Old World Tropics, frequently cultivated throughout the interior).

The leaves are undoubtedly of some use as fodder, especially for goats and possibly for cattle when properly dried; their use here however is almost entirely as nitrogen-fixing plants.

MAYA, Piñuela; Pinguin; *Bromelia Pinguin* L.

Probably indigenous. Common in waste lands and along sea coast. Planted in fence-rows and for hedges; 1–2 m. (or, in jungles, reaching 3 m.).

The fully ripe fruits contain considerable white juicy pulp, resembling in flavor the pineapple; like the under-ripe *piña*, however, the rhaphides contained in the pulp irritate the oral membranes.

MAY POPS. See **Parcha.**

MEJORANA; Sweet Marjoram; *Origanum Majorana* L.

This Oriental herb should be grown more widely here. The leaves and seeds are tonic-stimulant, in soups or stews, and (seeds) in pastry

MELISA; Balm; *Melissa officinalis* L.

This European culinary herb has grown well in the test plats at Trujillo; very rare in Island gardens. Some plants develop purplish leaves and stems. Recommended for general cultivation.

MELOCOTON; Peach; *Amygdalus Persica* L.

This strictly temperate European tree might endure the highest localities here for a few years. The following varieties were introduced in 1905 at the Experiment Station at Mayagüez: Angel, Bidwell Early, Bidwell Late, Jewel, Japan, Dwarf Blood, Peen-to, Red Ceylon, and Waldo: not even the Chinese Peen-to, nor the Red Ceylon, have proved to be acclimatizable. A few varieties were introduced about 1899; it is reported that some variety was brought in by the old Toa Grange about 1515. The Peen-to is considered a distinct botanical variety (*platycarpa* Bailey).

MELON; Muskmelon; *Cucumis Melo* L.

Only one variety is successfully cultivated to any extent here; this seems to belong to the true *Cantaloupe* type (var. *cantaloupensis*

Nandin) but does not have a hard rind; it is grown in the cooler hilly districts and is marketed both during the rainy and the dry seasons; it commonly weighs about 2 kilos, but may reach 4; the shape is oblong, moderately furrowed, fairly smooth; color dull yellow to pale cream with orange-yellow pulp. This excellent melon appears to be extremely rare both in Europe and America, but a similar variety is produced in Canada; though sometimes called *Melón de España*, it seems to be unknown there. Origin uncertain. It comes true to seed of local production.

A much rarer melon is found at times on the Río Piedras market; this is roundish, almost without furrows, quite smooth, orange yellow outside and paler within; flavor good; known locally as "Melón de América", but seems to be a purely local variety which happens to come true to seed here. Neither of these interesting native melons seems to belong to any of the 6 botanical varieties.

MELON. See **Condol.**

MENTA; Peppermint; *Mentha piperita* L.

This splendid old European seasoning herb has recently been established at the Trujillo Plant Propagation Station.

Here it is growing off apparently as well as the two acclimated mints which have been here for a long time. This will be distributed promptly.

MESQUITE; *Prosopis juliflora* (Sw.) DC.

Probably native forage tree, 3–10 m. Occasionally planted especially on south side of Island for the nutritious pods (for forage), pastures and roadsides. Probably 2 forms.

MILLET. See **Millo.**

MILLO DE AFRICA; Indian, African, or **Pearl Millet;** *Pennisetum glaucum* R. Br.

This old cereal and forage crop of unknown nativity has given fair results especially at the Trujillo Plant Propagation Station; it is, however, not cultivated to any extent here at present, either for human consumption or as a fodder plant.

MILLO DE ITALIA; German Millet, Italian Millet; *Chætochloa (Setaria) italica* Beauv.

This common European forage grain is very rare here but has given fair results at the Trujillo Plant Propagation Station.

MILLO SORGO; Kafir, Sorghum, Guinea-corn; *Holcus Sorghum* L.

Several varieties of this old Old-World crop are grown on a mall scale all over the Island, largely for poultry feed. Some 6 varieties have succeeded well at Trujillo Plant Propagation Statio and are being distributed. None of the molasses Sorghums hav been tested here, it seems.

MINT. See **Sándalo de Jardín.**

MINT. See **Yerba Buena.**

MIMUSOPS, Ciruela de Mozambique; *Mimusops marginata.*

Recently introduced from Mozambique through the Department of Agriculture at the Experiment Station, Mayagüez. Presumably only a second-class fruit tree but of value in the future breeding work of the Department with the lucumas and sapotes.

MIRRA DE JARDIN; Myrrh, Sweet Cicely; *Myrrhis odorata* (L.) Scop.

Old European seasoning herb. Has succeeded at Trujillo Plant Propagation Station, but not recommended for general planting.

MIRTO PELUDO; Downy Myrtle; *Rhodomyrtus tomentosa* (Ait.) Wight.

This Oriental species was introduced in 1903 through the U. S. Experiment Station in Mayagüez and began to fruit in 1905. Several specimens are in evidence about the island and it is expected that the tree will eventually become a popular small-farm fruit.

MOLASSES GRASS. See **Yerba de Melado.**

MOMBIN. See **Ciruela.**

MOMBIN. See **Jobo.**

MONKEY APPLE. See **Corazón Cimarrón.**

MORA BLANCA; White Mulberry; *Morus alba* L.

Introduced from Europe; second-class fruit shrub; 2–5 m. Fruit whitish, 2 cm. long.

MORA DE CHINA; Chinese Mulberry; *Morus multicaulis* Perr

Introduced primarily for silk-worm forage, but also a second-class fruit shrub, 3–8 m. Fruits black, 2 cm. long.

MORA NEGRA; Black Mulberry; *Morus nigra* L.

Introduced first-class fruit shrub, 3–8 m. or more. Rarely cultivated, but worthy of extensive planting. Asiatic. Fruit purple to black, 2–3 cm. Rapid grower and easily propagated.

MOSTAZA; Curled Mustard; *Brassica japonica* Sieb.

Rarely cultivated, but an excellent vegetable for soups and greens.

MUNG; *Phaseolus aureus* Roxb.

This bean was introduced (probably first by the U. S. Agricultural Experiment Station) about 1903. When carefully handled it fruits fairly well, and the small seeds make a delicious red purée. Too weak here to succeed as a forage crop. Possibly adaptable to soils too poor and dry for ordinary beans.

MURTA; *Eugenia axillaris* (Sw.) Willd.

A shrub or small tree in waste lands of the interior, 8–12 m.; also occurs on all the islands surrounding Porto Rico. Fruit black, smooth, round, 7–10 mm. in diameter.

MURTA; **Guava-berry**; *Eugenia floribunda* West.

A rather rare indigenous fruit tree which for many years has been quite famous in the American Virgin Islands (St. Croix, especially); 5–10 m. Fruit produced in the dry season, December to April, usually in enormous quantity. Formerly used as the basis of a special liquor which was exported to Denmark and various other countries in northern Europe. At present used in making an excellent but almost too strongly flavored jam. The dark red or nearly black fruits are 8–10 mm. in diameter and contain one fairly large seed: the pulp is intensely aromatic and fragrant and can probably be used for blending with less highly flavored fruits.

Three or four distinct forms of the species are known (at least in the Virgin Islands). Difficulty has been found in propagating this species at the Trujillo Plant Propagation Station.

MURTA. See **Caimitillo.**

MURTA (PALO DE); *Eugenia ligustrina* (Sw.) Willd.

This indigenous shrub or small tree, 5–8 m. high, is fairly common in waste lands on the south side of the Island and in Culebra and Vieques; the fruit is round, and about 8 mm. in diameter.

MUSKMELON. See **Melón.**

MUSK-SEED. See **Algalia.**

MUSTARD. See **Mostaza.**

MYRRH. See **Mirra.**

NABO; **Turnip**; *Brassica Rapa* L.

A very common vegetable; succeeds best in the cooler hills. Market season long. Nativity unknown. A white variety with a purple crown is much the commonest.

NAPIER GRASS. See **Yerba Elefante.**

NARANJA, Naranja Agria; **Sour, Seville** or **Bitter Orange**; *Citrus aurantium* L.

This old fruit is common everywhere in a semi-cultivated state, especially in the wild-orange region in the wetsern half of the

Island. Even allowing for its great vigor and rapid growth as a seedling, its abundance is not easy to explain, for it appears to have but little use as a fruit. As a stock for other citrus fruits (orange, grapefruit, etc.) it does have a place in Porto Rican citrology, though its long, over-developed taproot unfits it is a stock for planting in shallow soils. There are 3 or 4 varieties of this fruit here: the thinner-peeled bitter, the sour sour, and the sweet sour,—the two latter forms running together and varying in size, shape and color as well as texture and acidity.

The peel is a staple article in the drug and grocery trade; tests at the By-Products Plant at Mayagüez indicate that it can be dried readily, especially if just under-ripe, but that it does not grind so well as sweet orange peel. Tests there also show that a good cattle feed can be made from the peel, seeds, and pulp; the juice, at least from immature fruits, contains a fair amount of citric acid but the large percentage of gummy substances militate against the use of the juice for lime citrate.

The famous Curaçao variety used abroad in making liqueurs, etc., was introduced in 1904.

NARANJA DULCE. See **China.**

NASTURTIUM. See **Capuchina.**

NELLI; *Phyllanthus Emblica* L.

Second-class, recently introduced fruit tree, 4–10 m.; first planted (1903) at the U. S. Experiment Station at Mayagüez; established at College of Agriculture and Mechanic Arts; it gives a heavy crop of yellow, acid, roundish fruits, suitable for jellies and preserves.

NIGUA, Nigua de Playa, Temporana; Bay Lavender; *Mallotonia gnaphalodes* (L.) Britton.

An indigenous fleshy shrub found along the coast of Porto Rico and of the surrounding islands; 3–12 dm in height, with beautiful foliage and black, roundish fruits with a sweet-sour pulp. Much sought after by children.

NIGUA DEL MONTE; Chiggery Grapes; *Tournefortia hirsutissima* L.

A stout hairy vine, indigenous along river banks and forest borders; 3–5 m., becoming shrubby. Fruit white, roundish, about 5 mm. in diameter.

NIGHTSHADE. See **Hierba Mora.**

NISPERO; Sapodilla; *Sapota Achras* Mill.

A very common fruit tree, supposed to be indigenous, planted throughout the Island, largely for its very sweet fruit but partly for its dense shade; 5–15 m. The fruit of the common Porto Rican variety is only 5–8 cm. in diameter; the pulp is always consumed raw. The content of sugar runs up to 12.7 per cent. One of the most widely-grown, but unfortunately one of the rarest of the first-class fruits of the Island.

NOGAL, Palo de Nuez; Wild Walnut; *Juglans jamaicensis* C. DC.

Forest nut tree, 20–25 m. in western mountains. Perhaps worthy of cultivation. Nuts 4.5–5 cm. long by 4 cm. broad.

NOGAL INGLES; "English" or Persian Walnut; *Juglans regia* L.

Rarely planted experimentally. This first-class nut tree from China and North India seems ill adapted to this climate.

NUEZ DE LA INDIA; Candle-nut; *Aleurites moluccana* (L.) Willd.

A rather uncommon East Indian tree, 10–20 m., semi-cultivated throughout the Island. Apparently two forms exist, one with strongly purgative seeds and another producing nuts which are quite edible even when not roasted. The oil is not used here as in Polynesia.

NUEZ MOSCADA; Nutmeg; *Myristica moschata* Thunb.

This Oriental spice tree was introduced through the Experiment Station at Mayagüez in 1903 (and possibly previously) but has never succeeded very well. Several lots of seeds have been introduced during the last two years but the germination has been extremely poor. Mace and nutmeg seem to be comparatively unpopular spices here.

NUEZ DE PAN; Breadnut; *Brosimum Alicastrum* Schwartz.

This Jamaican fruit and forage tree has been introduced at the U. S. Experiment Station; 8–15 m. The fruit is round, yellow, about 2 cm. in diameter, with one large seed which is edible after roasting. The leaves, like those of the related breadfruit, are excellent cattle fodder.

NUEZ DEL PARAISO; Paradise Nut; *Lecythis Zabucajo* Aubl.

Introduced in 1924 at the Trujillo Plant Propagation Station from Trinidad, B. W. I.; seeds presented by Mrs. Eugene André,—together with a collection of ornamentals. While reaching 10–15 m. or more in its original habitat, plants have fruited at much smaller size in Trinidad, and it is hoped that it will bear here at the height of 5 m. One of the finest table nuts in the world: richer than the true Brazil-nut (*Bertholletia* spp.), but sometimes slightly bitter.

NUEZ DE QUEENSLAND; Queensland Nut; *Macadamia ternifolia* F. Muell.

This splendid large (up to 15 m.) nut tree has been introduced at the Federal Agricultural Experiment Station from Australia *via* the U. S. Department of Agriculture. The very hard-shelled nuts have an excellent flavor and the tree has given fair satisfaction in several countries outside of its original habitat.

NUTMEG. See **Nuez Moscada.**

ÑAME DE AGUA, Ñame Blanco; Water Yam; White Yam; *Dioscorea alata* L.

By far the commonest yam in the world and much the most variable; probably native to Southern Asia, but now cultivated in most tropical countries. Never cultivated here in large fields, but semi-cultivated in fence-rows, field margins and thickets. The vine may attain 15–20 m. and each old root may have several vines.

The stem is always angled; the (usually four) thin membranaceous appendages of these angles are generally colored red or purple and are sometimes transparent; another species, the Yampee, has similar wings on the stems.

The leaf is dictinctive in having 5 to 7 strong veins, a winged petiole, and a thick glossy blade more or less heart-shaped. How such a plant with apparently weak, soft, sappy leaves and stems can resist long droughts better than any other similar class of plants, is a mystery.

Most of the many (probably 30 or more) varieties of these "Ñames de Agua" produce axillary bulbils, sometimes of considerable weight.

The shape of the roots is very irregular, but seldom cylindrical. The color of the fecula varies from snow white through yellow shades to pink, lilac, and even purple.

ÑAME AKAM; Akam Yam; *Dioscorea latifolia* Benth.

This rare yam from West Tropical Africa is sometimes cultivated here and is confused with the old (Indian?) species *D. sativa;* leaves, 7-to 9-nerved and cordate.

ÑAME AMARILLO; Yellow Yam; *Dioscorea cayennensis* Lam.

One of the three commonest yams, closely resembling the Guinea, but differing in the more angular basal lobes of the leaf and in the less cylindrical roots which are always more or less yellow as to the *fecula* and the peel (toward the tip).

This slightly variable species probably originated in the West Indian region. It is hardier than the Guinea and can maintain itself in any dry situation.

ÑAME BLANCO. See **Ñame de Agua.**

ÑAME DE CHINA; Chinese Yam; *Dioscorea Batatas* Decne.

This rare and very interesting old species has recently been introduced; propagating at the Trujillo Plant Propagation Station. The very slender roots sometimes attaining a length of 1 m. or more are of fairly good quality and may be of value under certain soil conditions here.

ÑAME GUAYARO, Gulumbo; *Rajania cordata* L.

An interesting indigenous yam which refuses to be domesticated; 5–10 m. Grows wild on the Experiment Station grounds at Mayagüez. Vine slender, smooth, with variable leaves.

The exceedingly slender roots may attain a length of 1 m. with a diameter of only a few centimeters; their flavor, when mature is exquisite, sweeter and more delicate than that of most yams. On account of the difficulty of digging them, these roots are not marketed, unfortunately.

ÑAME GUINEA;* Guinea Yam; *Dioscorea rotundata* Poir.

This is the best of the common yams and is cultivated throughout the Island, though only in the western third is it grown in regular fields. The plant here is always supported on stakes (about 1.5–2 m high), the vines attain a length of 3–6 m. the leaves are very dark green, thick, and heart-shaped; the stem is round and armed with curved spines near the base.

The roots are more nearly cylindrical than in any other species; weight from 2 to 20 kilos; surface grayish brown or (on the distal half) streaked with yellowish, peel corky and longitudinally ridged

ÑAME GUNDA, Dunguey; Air Potato, Turkey-liver Yam; *Dioscorea pilosiuscula* Bertero

A probably indigenous wild species of the waste lands and forest borders; 10–15 m. Vine slender, nearly cylindrical; leaves bear large, peculiar-shaped, smooth bulbils (like *D. alata*) in their axils, and presumably these, rather than the seeds, are the plant's means of dispersion.

Old plants, produce small, roundish, coarse roots, suitable only for pig feed (when cooked). The axillary "potatoes" are too bitter to use for human food unless cut up and soaked in water for a day or two before cooking; they may weigh up to 300 or 400 grams and *can be kept a year.*

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* Britton & Wilson states that this species was "originally described from (probably cultivated) Porto Rican specimens' However, since this yam seems to be quite distinct from *D Cayennensis* (probably a South American plant) and since we must at least pay some respect to the common name which seems to be unusually fixed there is excellent reason for believing that this very important food plant was brought to the Island by the slave ships some time during the 16th century from the Gulf of Guinea region It appears similar species occur in India and quite possibly the Portuguese brought these yams from thence to the West African coast

ÑAME HICAMO, Gunda; *Dioscorea polygonoides* H. & B.

One of the 4 or 5 formerly very common wild yams of waste lands and open thickets throughout the Island. Vine smooth, nearly cylindrical

Root large, coarse, frequently deeply buried.

ÑAME MAPUEY; Yampee; *Dioscorea trifida* L. f.

The comparatively small number of varieties comprised under this species form a group of very distinct yams, generally conceded to be the best for table use; their low yielding qualities and somewhat tender nature offset their excellent roots. Mapuey yams are fairly common in all sections of the Island, but they are seldom grown on a large scale; the roots bring about double the price of ordinary yams. They can be grown without poles. The color of the fecula ranges from nearly white to a dark purple.

Only two varieties have been widely grown here; the Blanco and the Morado, the former being considered the better for general planting, but the latter is very highly appreciated—probably, the most expensive root on the market.

Several forms of the Yampee from other West India islands have been well distributed about Porto Rico, but their yield is light and the people do not yet appreciate them.

The Yampee type attains a length of 5–8 m. but the Mapueys are the smallest of all cultivated yams, 1–2 m.

Unquestionably a native of South America.

ÑAME PAPA; Potato Yam; *Dioscorea esculenta* (Lour.) Prain. Benth

A rare species of much promise introduced several years ago. The Experiment Station at Mayagüez has for years distributed propagating material to farmers, but it does not appear on the market as yet. Probably of African origin. One excellent variety was discovered in the Canal Zone in 1915 whither it had been brought from old Panamá India gardens; but it is now apparently lost.

ÑAME DUNGUEY; *Dioscorea altissima* Lam.

One of the largest and perhaps the oldest of the indigenous West Indian yams; probably used as food many centuries ago here. Hardly any limit to its length, readily ascending to tall tree-tops. Rarely cultivated, if ever, here now.

Vine armed with large flat prickles; below sharply angled and even winged, brownish; even the petioles sometimes armed with small thorns.

Root coarse, very irregular, bearing many wiry rootlets.

OATS. See **Avena.**

OHIA; Pomarrosa de Malaya; Malayapple; *Jambos malaccensis* (L.) DC.

First-class introduced (East Indian) fruit tree, 5–20 m.; less than a dozen mature trees (near Río Piedras) known, but hundreds are being propagated; distributing from the Plant Propagation Station. Both a dessert and jelly fruit; skin scarlet, pulp white, the pronounced rose bouquet of the fruits persists after cooking. Two forms, one obconical (8–10 cm. long) and one roundish (smaller) are in evidence here; seeds of the latter were also brought from Dominica Botanical Gardens in 1924.

OKRA. See **Guingambó.**

ONION. See **Cebolla.**

ORANGE. See **China.**

ORANGELO; *Citrus sinensis* X *C. grandis.*

This new hybrid fruit of great promise was introduced (Dec. 1924) through the Plant Propagation Station at Trujillo.

OREGANO; Pot Marjoram; *Origanum vulgare* L.

A very popular European savory herb, grown in nearly every large garden; 1–1.5 m.

OREGANO BRUJO; Oriental, or Spanish Marjoram; *Coleus amboinicus* Lour.

One of the best and commonest seasoning herbs of the Island and one which should be in every kitchen-garden. Probably Malaysian. Apparently non-variable. The thick, juicy stems reach a height of 5 dm. or more. Frequently grown in tins and pots but fairly hardy in a partly shaded bed.

OREGANO CHIQUITO; Porto Rican Marjoram; *Lippia Helleri* Britton

One of the commonest Porto Rican flavoring herbs; 1–2 m. Stems distinctly woody, very slender. Leaves only 5–12 mm. in length. Bouquet rather stronger and better than the Common Orégano. *Endemic.* This remarkable plant should be distributed to all other tropical countries.

OREGANO DE ESPAÑA. See **Orégano Brujo.**

PAJUIL, Cajuil, Marañón; Cashew-nut; *Anacardium occidentale* L.

Probably native, extremely common tree, 8–12 m., seldom really cultivated but common throughout the island in fence-rows and around hills near the sea shore, particularly near Vega Baja. Apparently not variable; fruits of both yellow and red colors, however, are in evidence and there is considerable variation in size of fruit. The pulp of the sour fruit is sometimes cooked up into dulces and is much relished raw by many people; the juice is astringent. The kernel of the seed is very much appreciated but although sold occasionally in the markets is never exported here (as is done in Haiti).

PALM. See **Palma.**

PALMA DE ACEITE;. **African Oil Palm**;- *Eleis guineensis* Jacq.

Introduced by the Experiment Station at Mayagüez; not seen outside. In Africa (Liberia and Sierra Leone, especially) reaches 15 m. Six or 8 types, with several minor "connecting link" forms. are known in West and West Central Africa.

PALMA DE AZUCAR; **Sugar Palm**; *Arenga pinnata* Merrill.

A few specimens, raised from seeds sent from the Orient and planted by the author at the Experiment Station in Mayagüez, in 1903, have fruited. Native to Philippine Islands, 6–12 m. Seedlings have been distributed. One mature specimen may be seen near "Stop 33" north of Río Piedras. Neither sap, seeds, nor sago (pith) used here.

PALMA DE BETEL; **Betel-nut Palm**; *Areca Catachu* L.

Numerous specimens grown as an ornamental at San Sebastián. Introduced from Orient; 4–6 m. Nuts not used here.

PALMA DE COROZO; **Gru-gru Palm**; *Acrocomia aculeata* (Jacq.) Lodd.

Very common native palm; 4–10 m.; prefers dry locations. Never cultivated. No variation. Nuts sometimes used. "Cabbage" bud seldon used, but edible. Oil can be made from kernels.

PALMA DE DATIL; **Date**; *Phœnix dactylifera* L.

Numerous specimens, rarely fruiting well, especially on south side of Island; 5–10 m. African origin. Treated as ornamental, cultivation might succeed in southwestern part of Island.

PALMA REAL. See **Palma de Yagua.**

PALMA DE TALIPOT; **Talipot Palm**; *Corypha elata* Roxb.

A few specimens were raised from seeds sent from the Orient, at the Federal Agricultural Experiment Station in 1903; one magnificent specimen appears nearly ready to flower; height 13 m., trunk 1 m. in diameter; leaves 4.5 m. in diameter.

PALMA DE VINO; Wine Palm; *Caryota urens* L.

A few specimens were planted at the U. S. Agricultural Experiment Station in 1903; some have flowered. Occasionally cultivated as ornamental; 8–15 m. Sap not used of this (nor of any other) species of Palm here. Oriental.

PALMA DE YAGUA, Palma Real; Porto Rican Royal Palm; *Roystonea borinquena* O. F. Cook.

Endemic species, 8–20 m.; prefers wet districts. Seldom actually cultivated. Seeds constitute important feed for swine; ground at By-Products Plant and used on Model Farms with or without admixture of other feedstuffs for pigs only. Crop, June to September; sometimes transported in bulk to localities where these palms are not abundant; seeds endure storage well. "Cabbage" rarely used here.

PALMA DE YAGUA DE CUBA; Cuban Royal Palm; *Roystonea regia* (H. B. K.) O. F. Cook.

Introduced about 1903 at the U. S. Agricultural Experiment Station, 8–20 m.; good fruiting specimens in evidence. Seeds like *R. borinquena* but purplish instead of light brown. Habitat, Florida, Cuba, Haiti.

PALO DE MURTA. See **MURTA, Palo de.**

PALO DE NUEZ. See **Nogal.**

PALO DE RAMON. See **Ramón.**

PALO DE VELA; Candle Tree; *Parmentiera cerifera* Seem.

This interesting Panaman tree was introduced a few years ago at the Federal Agricultural Experiment Station: 4–10 m.; seedlings have been distributed. The slender cylindrical fruits, appearing as if made of wax and bright yellow when ripe, are eagerly devoured by cattle: if eaten in large quantities these fruits give the meat an apple-like taste. The bark also is eaten by cattle,—stripping the trunk up as high as they can reach.

PAMPANO, Plátano de Indio, Bihai; Wild Plantain; *Bihai Bihai* (L.) Griggs.

This very common old relative, if not ancestor, of the plantains and bananas was undoubtedly used for food by the aborigines; 3–5 m.; moist ravines from sea-coast to mountain-top.

The massive, irregular-shaped rootstock, though containing coarse fibers (like the Bananas) has considerable starch and could well be used today for pig feed.

PANA; Seedless Breadfruit; *Artocarpus incisa* L. f.

This splendid old Polynesian fruit tree was probably introduced here in the early part of the 19th century.

Though nowhere planted in groves it is fairly abundant in all districts, except, perhaps the driest. The difficulty of propagating it (from root cuttings and sprouts) and its liability to die back at the tips of the upper branches militate against its more general planting; besides, it (like the yuca) is looked upon as a cheap low-grade food fruit hardly worthy of gracing the tables of the well-to-do. Yet, if the small farmer had to restrict his number of food fruits to *one species,* evidence indicates that not the plantain, nor the avocado but the Breadfruit should be chosen to supply the needs of the family and the domesticated animals; for, it must be remembered, not only does it furnish 2 or 3 crops of the very wholesome large fruits every year, but its luxuriant leaves constitute (fresh or dried) a nutritious fodder, relished alike by the cattle, goats and horses; while any surplus fruits are eagerly devored by swine, cattle, and even (when cooked) poultry.

It usually begins to bear at 3 or 4 years from the rooting of the sprout, and may live 20 to 30 or more years, attaining a height of 15–25 m.

Soon after the opening of the By-Products Plant in Mayagüez in October, 1923, some 10,000 fruits were dehydrated and made into a meal for feeding the breeding cattle on the Model Farms; the average weight of the fruits was nearly 1 kilo and the cost of the meal ("Breadfruit flour"), using the entire fruit, sliced, dried, and ground, was only about 2½ cents per kilo. A higher-grade flour for human consumption was prepared from the pulp alone; this, like the feed, keeps well for many months. While there are some 200 varietal names of this and the Seed Breadfruit species scattered throughout Polynesia and Melanesia—probably representing about 100 distinct forms, there are today in the Western Hemisphere only the two species represented here and one other extremely rare form intermediate between these two found (in the author's knowledge) only about Greytown, Nicaragua. Presumably some of the Polynesian races would do even better here than the said two which have been in evidence here for some 135 years.

Here the fruit is never used in a fermented state, as (frequently) in Polynesia; but boiled, baked, or fried it is one of the farmers' cheapest foods; mashed and mixed with peppers, cheese, spices, meat, etc., it forms a rich, easily digested *piece de résistence.*

The following analyses are illuminant:

	Breadfruit flour	Breadfruit leaves
Proteins	6.169 per cent	24.39 per cent
Fats	1.600 per cent	6.58 per cent
Carbohydrates	75.831 per cent	34.83 per cent

PANA DE PEPITA; Seed Breadfruit; *Artocarpus communis* Forst.

This species, presumably brought into the West Indies in 1793 with the seedless breadfruit (*A. incisa*) by Captain Bligh; now thoroughly naturalized throughout Tropical America and of considerable importance though not as compared with the seedless breadfruit; 8–20 m. This species can readily be distinguished even at a distance from the true Breadfruit by the closer branch habit, by the smaller leaves and by the much less incised margin; whereas the leaf of the true Breadfruit is cut in almost to the mibrid, the leaves of this species are cut in only about half way. The fruit moreover of this species is always covered with numerous short fleshy spines, instead of presenting a fairly smooth surface. The seeds are commonly used throughout the Island not only as human food (when boiled in salted water) but are also of considerable value as a pig feed (raw and cooked). If fully matured the seeds are inclined to have a bitter taste but if the fruit is harvested just before maturity the seed bitterness is not noticeable in the *fécula*. The entire fruit when thoroughly ripe is an excellent pig or cattle feed. Experiments at the By-Products Plant in Mayagüez indicate that this fruit can be easily sliced, dried and ground into a very nutritious cattle and pig feed,—even better than that of the Seedless fruit (on account of the high protein content of the seeds). The leaves of this species as well as of the other, whether fresh or dried and ground into a meal, are first-class fodder for the domesticated animals. The leaves may be removed 2 or 3 times a year without seriously injuring the tree's vitality. Naturally, if many leaves are removed the crop of fruits will be proportionately reduced.

PANAMA; Wild Alocasia; *Alocasia macrorhiza* (L.) Schott.

One of the most conspicuous and widest spread weeds in the Island. Probably Oriental. In rich wet soil reaching 2–2.5 m. The rhizomes, almost entirely above ground, attain a diameter of 10–20 cm.; though poisonous (from the calcium oxalate rhaphides) raw, thorough boiling renders them fit for pig feeds. Never cultivated.

PAPA; Potato; *Solanum tuberosum* L.

The date of introduction of this South American species is unknown but has never until the last 25 years obtained any great importance in the island. From time to time small fields of common European or mainland varieties have been grown with partial success in the cooler districts. The presence of the tropical potato blight (*Bacillus solanacearum*) in (presumably all of) the soils of the Island militates strongly against commercial success with this crop here. While very fine specimens of tubers weighing up to one kilo can be grown in the mountainous regions, the average plant becomes so severely attacked by the said blight before its maturity that the growth of the tubers is checked so that the weight of edible tubers per plant is considerably below the economic yield.

Several European varieties, supposed to be resistant to the blight, are being tested at Cayey Model Farm and Trujillo Plant Propagation Station. The plant seems to be fairly free here from insect pests. Possibly some of the violet-skinned types from Colombia and Peru and hybrids with *S. Commersonii* might resist the bacillus here much better.

PAPAYA. See **Lechosa.**

PAWPAW. See **Lechosa.**

PARCHA; Bell Apple; *Passiflora laurifolia* L.

A rather rare woody vine, introduced through the Plant Propagation Station at Trujillo where numerous plants are ready for distribution; 5–10 m. Fruit yellow when ripe, with a hard shell, egg-shaped, 6–7 cm. long; pulp sweet and very aromatic, fragant.

PARCHA, Curuba; *Passiflora maliformis* L.

An indigenous wine, sometimes cultivated for its fruit; also occasionally wild in the waste lands of the wet districts of the Island; 5–10 m. Fruit round, with a hard shell, about 3 cm. in diameter. Pulp fragant, delicious, seedy.

PARCHA ENCARNADA; May Pops; *Passiflora incarnata* L.

This North American species was introduced in 1923 through a private garden at Ensenada.

PARRA; Wild Grape; *Vitis tiliæfolia* H. & B.

This widely distributed wild grape has long been known under the name *Vitis caribæa* DC., and has been used as a stock for other (hybrid, or cultigen, varieties); 5–15 m.; occurring in jungles and along banks of streams in the moister districts. Fruit 10–12 mm., purple.

PARSLEY. See **Perejil.**

PEA. See **Petit-Pois.**

PEACH. See **Durazno** and **Melocotón.**

PEACH PALM. See **Pejibaye.**

PEANUT. See **Mani.**

PECAN; *Hicoria Pecan* (Marsh.) Britton.

Rarely and only experimentally planted. First-class nut tree. Probably cannot endure continuous summer.

PEJIBAYE; Central American Peach Palm; *Guilielma utilis* Oersted.

Introduced in 1924 by the Department (presented by the U. S. Department of Agriculture, Washington, D. C.) and growing slowly at Model Farms, and Plant Propagation Station. The orange or red fruits contain a very nutritious dry, sweet pulp covering the useless seeds; pulp must be boiled, steamed, or roasted. Central American. A seedless variety known.

PEPINILLO; Gherkin; *Cucumis Anguria* L.

This West Indian relative of the Cucumber is quite common in the cooler districts, and marketed in considerable quantities. Seems to vary remarkably little.

PEPINO; Cucumber; *Cucumis sativus* L.

Though this old (probably African) vegetable is very subject to pests, diseases, and troubles from drought and bad soil conditions, it is fairly common in most districts but is grown mostly for sale (at high prices) in the larger markets. Eaten fresh (in salads) and seldom pickled here.

PEPINO ANGOLO, Curuba; Cassabanana; *Sicana odorifera* (Vell.) Naud.

This very interesting old vegetable (probably Brazilian) is common in most markets during most of the year, yet is very seldom seen on the vine. Its flavor and odor are exceedingly strong and render it unpopular as a cooked vegetable, even for dulces; but it is said to have great value in making medicinal beverages. Its keeping qualities are remarkable; one of the brownish red cylindrical fruits (30–50 cm.) may be kept hanging in a fruit booth for a week or more, pieces being cut from the bottom as required and a piece of paper stuck over the cut surface to prevent decaying.

PEPPER. See **Pimiento.**

PEPPER, DEVIL. See **Ají.**

PEPPERMINT. See **Menta.**

PERA; Pear; *Pyrus communis* L.

Even at the highest elevations, the cultivated pears are likely always to be a failure here. There is an interesting belief among small farmers that the seeds of the Pear (and Apple) grow into

Guava trees. The varieties Le Conte and Keiffer were introduced in 1905 at the U. S. Experiment Station at Mayagüez.

PERA DE ANCHOA; Anchovy Pear; *Grias cauliflora* L.

A third-class Tropical American fruit tree, 3–10 m.; leaves exceedingly large on the ends of branches; large white or yellowish flowers on the branches. Fruit 5–7 cm. long, brownish, fleshy, with one large seed. Distributing from the Plant Propagation Station at Trujillo. Presented by the Dominica Botanic Gardens.

PEREJIL; Parsley; *Apium petroselinum* L.

A common savory vegetable, widely cultivated but on a small scale only. Several varieties grown. Mediterranean. The variety *Crispum* DC.; is not so common; and the variety *radicosum* Alef. is very seldom attempted here.

PERIFOLIO. See **Cerafolio.**

PERIFOLIO LEVISTICO; Lovage; *Hipposelinum Levisticum* (L.) Britton & Rose.

This old South European culinary herb (related to Chervil), recently introduced from France, is growing well at Trujillo Plant Propagation Station.

PERUNKILA; *Arduina Carandas* (L.) Britton var. *dulcis* P. J. Wester.

An Indian fruit, introduced in September 1924 from the Philippine Islands (Bureau of Agriculture); distributing from Plant Propagation Station. A sub-acid, juicy, black, grape-like fruit. Described (Bul. 39, 3rd. ed., of Philippine Bureau of Agriculture) by P. J. Wester as new variety probably distinct from the true Karanda.

PETIT-POIS; Pea; *Pisum sativum* L.

With inoculated soil this temperate vegetable may be grown, especially in the higher districts (reaching 2 m. at Villalba,—P. R. Tropical Products Corp.). Becoming less rare. Apparently the only food plant here bearing a French name.

PE-TSAI; *Brassica pekinensis* Rupr.

A rare, recently introduced Chinese vegetable; cultivated only occasionally in kitchen gardens. Succeeds fairly well at Trujillo Plant Propagation Station.

PIGEON PEA. See **Gandul.**

PIMIENTA; Allspice; *Pimenta Pimenta* (L.) Cockerell.

This Jamaican species is sometimes planted in Porto Rico and neighboring islands as a spice crop though never more than a few trees are in evidence at any point; 4–8 m. The spice is scarcely of any commercial importance here.

PIMIENTO; Red Pepper; *Capsicum annuum* L.

Probably some forms of this pepper were used by the aborigines here. The principal varieties in common cultivation now belong to the botanical variety *grossum* Sendtner, which includes the bell peppers; several horticultural forms of these are popular. Their season is very long.

PIMIENTO LARGO; Long Pepper; *Piper incurvum* Sieber.

The remarks given under black pepper apply also to this species.

PIMIENTO NEGRO; Black Pepper; *Piper nigrum* L.

The Trujillo Plant Propagation Station possesses a few plants of this interesting species, brought in in March, 1924, from the Dominica Botanic Gardens. The fleshy leaves are eagerly eaten by poultry. Recommended for cool moist situations.

PINEAPPLE. See **Piña.**

PINGUIN. See **Maya.**

PIÑA; Pineapple; *Ananas Ananas* (L.) Cockerell.

Undoubtedly from Brazil, now widely cultivated throughout the Tropics as one of the four most popular fruits in the Torrid Zone.

The central section of the north coastal plain is the present center of the crop; formerly the southwest corner produced nearly all the fruits, and canning operations began there in 1902. The present area under cultivation is about 2,500 acres. During the first years of the Great War the annual export shipments amounted to about half a million boxes; now some 250,000 to 300,000 crates go out. The canned fruit (sliced and grated) now amounts to some 1,500,000 pounds.

Though probably introduced early in the 16th century, it appears that the piña was never grown for export till about 1870; the Cabezona was planted extensively then in the Lajas-Palmarejo district; there is still considerable acreage there. The introduction of the Red Spanish (probably from Florida) about 1900 gave the exporters a safe line of development; today it is the only variety planted on a large scale here.

The following varieties, brought in mostly by either the Federal or Insular Departments of Agriculture (since 1902), are established:

Cabezona; the largest variety (with the possible exception of the King, of Borneo) in the world,—the record fruit here weighing about 14.5 kilos. Used in high-grade canning in the old Lajas district.

Caraqueña; Resembles the "native" "Pan de Azúcar" but has a rougher surface.

Negrita; A semi-cultivated old variety; color dark, but flavor very fair.

Pan de Azúcar, or *Sugarloaf;* very commonly cultivated for home consumption; size fair; very sweet.

Red Spanish; the export and canning variety cultivated for many years throughout the Bayamón and Vega Baja–Arecibo sections; not recommended for the texture or flavor of its pulp, but it is the *piece de résistence* of the canner as well as the shipper.

Smooth Cayenne; a fine old favorite with few or no spines on the leaf margins; large plant with a first-class fruit. A large direct (*via* New Orleans) shipment of suckers was received in 1923 from Hawaii.

Several unnamed varieties have been presented in 1925 by the U. S. Department of Agriculture.

The following varieties have been brought in from Dominica, Jamaica and neighboring islands:

*Bullhead;** *Black Antigua; Ruby; Ripley.*

PIÑUELA. See **Maya.**

PISTACHE. See **Pistachio.**

PISTACHIO; Pistache; *Pistacia chinensis* Bunge.

Recently introduced first-class Asiatic nut-tree, 5–10 m.; at both Experiment Stations. May succeed better at Villalba and Sabana Grande Model Farms.

PITAJAYA; Night-blooming Cereus; *Hylocereus undatus* (Haw.) Britton & Rose.

A rather large climbing species, up to 7 m. in length, sometimes covering trees with its heavy 3-winged stems; cultivated; introduced from México; fruit 6–10 cm., red, with white pulp and black seeds. A very fine fruit, the pulp making a good drink, especially with ice and sugar.

PITAJAYA; *Hylocereus trigonus* (Haw.) Safford.

This common cactus produces large (6–10 cm. long) roundish fruits which resemble nothing else very closely in the whole Vegetable Kingdom. When well ripened the Pitajaya is a first-class fruit; it should be eaten fresh, though it may be preserved, and in Central America is often used in preparing cooling drinks.

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* According to Mr. H. C. Henricksen, Specialist in Farm Management, of the U. S. Experiment Station, at Mayagües, and a recognised authority on Pineapples, states that this variety was supposed to be identical wih our Cabezona, but he found it to be quite distinct.

It grows readily on any rough-barked open-topped tree, its roots clinging to but not injuring the host tree. Deserves a place in every fruit collection. Its white flowers which open at night, average about 15–20 cm. in diameter.

PITAJAYA; Sebucan; *Leptocereus quadricostatus* (Bello) Britton & Rose.

A branched species, 2–4 m. high, peculiar to the dry districts on the southwestern portion of the Island and to Icacos. Fruit reddish, 3–5 cm., smooth when ripe.

PITAJAYA AMARILLA; *Harrisia portoricensis* Britton.

A rare species peculiar to the southern coast near Ponce and Tallaboa and to Mona Island; slender, 2–3 m. high, fruit yellow or reddish, 4–6 cm in diameter.

PLATANO; Plantain; *Musa paradisiaca* L.

Though frequently (in commerce and in the public conception) confused with the Banana (*M. sapientum* L.) the true Plantains may be distinguished by the following characters: the bracts composing the terminal and unopened portion of the inflorescence are thinner and by the time the fruits are half grown the said bracts become shriveled and hang loosely at all angles with the rachis—while in the banana they remain fresh and close-packed in the ovate, pointed "bud" at the tip of the "bunch"; the fruits (except, perhaps, in the Maricongo and the aberrant Chamaluco) are borne loosely in the (few) "gajos", or hands, instead of being closely appressed, and their distal extremities are usually prolonged into a "beak", or point, 2–5 cm. beyond the pulp; the ripe pulp is more pasty and "gummy" and is less wholesome when eaten uncooked

The origin of the so-called "native" Plantains was presumably South Asia; they probably came around the Cape of Good Hope (with the Banana) in the 15th and 16th centuries into the West African countries and the East Atlantic Archipelagoes (Cape Verde Islands, the Canaries, Madeira, and the Azores). Since in historic times the Plantains have not been propagated from seeds, since very seldom do any of the 50 to 75 distinct cultivated varieties ever produce viable seeds, and since practically never is evidenced the slightest degree of variation in leaf, flower, or fruit characters, it is obvious that we have in this almost indispensable food plant the product of many centuries of cultivation; some of the varieties may have originated as horticultural "bud sports" but probably most were descended from wild races, several of which seem to be in evidence still in Southeastern Asia, the Philippines, and the East India Islands.

This species, taken as a whole, is beyond question the most important food-producing fruit species here today. While closely resembling the banana in habit, the true plantain flower-bud, or pámpana, is very close to the distal end of the bunch of fruits, is much smaller, looser, and shorter and it tends to dry and shrivel before the (comparatively fewer, usually) fruits reach maturity.

Less than 12 distinct varieties of Plantains are in evidence here now. All the many (probably 75) Oriental and (few) African varieties should be grown here in a comparative test; many would probably prove more or less immune to the banana disease and some might well excel these old varieties. It appears no plant of any of the Polynesian Plantains (*M. Fehi*), with upright fruit bunches and violet-colored sap, has ever been brought to Porto Rico.

The true Plantains resist the banana disease much better than do the common Bananas: the Chamaluco (not a true Plantain) is even more susceptible than the banana.

None of the following Plantains should be eaten raw, even when fully ripe. Boiled, fried, or roasted these comparatively expensive but highly nutritious and most wholesome fruits constitute an almost indispensable part of the Porto Rican farmer's diet. Moreover, very few food plants of any class or clime equal the Plantain in economical productiveness; unless weeds or droughts prevent, a crop of fruits (among the most nutritious known), is almost certain; strongs winds, cattle and root weevils are, however, to be reckoned with.

Ceniza; a sub-variety of the Chamaluco, having the fruits much paler and covered with an ashy bloom, whence the name. Like the Chamaluco, it is badly affected by the banana disease. Fruits practically inedible in the raw state, but considered as superior to the regular Chamaluco (more plantain-like) when cooked.

Chamaluco, Mafafo; formerly the commonest variety of plantain in the Island, but since the banana disease began to spread so disastrously (first noted by the author in 1902 and recognized as a serious disease about 1908) it has been almost exterminated in some districts, this variety being more severely attacked than any other Musa here, though it is apparently, as to soil and climatic conditions, the hardiest of all

The short, thick-peeled, strongly angled fruits are seldon eaten raw but are made into a great variety of dishes, boiled, fried, roasted, or mashed and mixed with meat, cheese, and other vegetables for frying in small cakes.

This once very cheap and popular old variety (of uncertain, but probably Philippine origin) seems doomed to soon disappear from the farms of Porto Rico.

Judging from its flower-bud, this variety is not a true Plantain, but an intermediate type between the Banana and Plantains.

A monstrosity variety, known as Pata de Pato, has the fruits more or less grown together in the hands.

Congo, Congo verde, Congo legítimo; this is by far the commonest of the lesser plantains. The bunch is larger than that of the Plátano Hartón. The fruits are strongly curved (which distinguishes them from the Maricongo) and the peel is thin.

Congo Morado; an extremely rare Plantain having fair-sized fruits which are dull maroon or purplish until nearly full grown, when they gradually turn to dark green color. Practically never brought to the large markets, though apparently just as a good for home consumption as any of the Plantains. This remarkable Plantain deserves our best attention.

Congo Prieto; a very rare variety, probably becoming rarer, from the west end of the Island. The beautiful fruits are peculiar in being purplish or reddish black from the time of flowering to maturity. The plant has more color on the stem and petioles than any other Plantain except the Cuarenteno. The quality of the fruit seems to be average.

Criollo, Prieto, Vinagre; a fairly common but unpopular variety: vigorous and productive; but the fruits are sour, gummy, and require thorough cooking. Formerly the ripe fruits were used in making excellent vinegar, and in some back districts this interesting custom still prevails.

While it may be claimed that this is a "primitive" variety, or possibly, a sport from the chamaluco, its origin must remain very uncertain; and though it sometimes produces seeds here, it does not appear to be at all closely related to the really primitive bananas and plantains of the Philippine Islands, many (probably 25) varieties of which bear viable seeds in almost every fruit.

Cuarenteno; one of the most striking and distinct of our Musas, yet unfortunately rare. The young leaves are heavily blotched and marbled with maroon and chocolate-colored spots and the midrib and under surface are shaded purple; they are like those of the Congo Morado except *in habit* they are like those of the Chamaluco. Even the fruit is purplish when young. Should be in all collections.

Enano; the smallest of the Plantains. The plant stem is decidedly short (2.5–3 m.), yet the bunch is frequently so heavy that it must be propped up to avoid being blown down by the wind; the fruits are comparatively large and of excellent quality. Recommended for sheltered situations.

The plant is much shorter (2.5–3 m.) than the ordinary Guarán, but the bunch and the fruits are both comparatively larger. The rachis is long and the naked part (between the "pámpana", or bud, and the terminal hand) readily distinguishes it from the true *Enano.* The fruits are plunt-pointed, sweet, and very plump. An excellent but top-heavy sort. Precocious, fruiting in 9 or 10 months.

Guayabo; the best of the 3 or 4 forms of the Chamaluco type. The peel is usually much cracked and may become brownish. The pulp is considered decidedly superior to that of the regular form.

Hartón, Macho; this is the most important food fruit variety common than the smaller forms of Plantain, or than the Guineo Guarán. The size of the fruit varies greatly according to the vigor of the plant but the comparatively short-pointed and weak-angled fruits are distinctive.

Possibly the Plátano Puro of the Ponce district is distinct: it seems to be straighter and less angled.

Though the market price is comparatively very high, one medium-sized fruit costing, say, 6 to 10 times at much as a Red banana, it is obtainable practically every day in the year in nearly every market of the Island. Fortunately, it keeps very well in storage, and is always brought to market in the "full" but green state and slowly ripened in heaps or in barrels; this fact, however, does not prove that the fruit is better treated thus than it would be if it could be safely (*sic*) left on the plant till fully matured. When the peel has turned from green to a dull yellow or, later, when the rather thick peel has become more or less black from bruising and decay, the fruit is known as an "amarillo" and is ready for frying, boiling, or baking; this term is also applied to all the Congos and the Maricongo,—but not to the Chamaluco.

The flour made by peeling, slicing, drying and grinding the nearly ripe (but not yellow) fruits has long been famous throughout Tropical America as an invalid and infant food; it appears to possess some tonic quality for the intestinal membranes, and has undoubtedly saved many lives, not only here but also in Tropical Africa, from the insidious diarrhœas and dysenteries which frequently fail to respond to ordinary remedies. Many hundredweight of plantain flour have been made at the By-products Plant in Mayagüez since December, 1923; some of this has been purchased by hospitals and individuals in the mainland. The peels and stems cut in small pieces, dehydrated and ground to a coarse meal make an excellent feed for livestock.

The analyses of the flour and the feed are as follows:

	Flour (fécula)	Feed (peels, etc.)
Fats (est.)	6.00 per cent	5.77 per cent
Proteins	3.09 per cent	6.43 per cent
Carbohydrates	68.77 per cent	71.78 per cent

Maricongo; the commonest of the lesser Plantains. The fruit generally weighing about one-half as much as the Plátano Hartón; the bunch has several or many times as many fruits as does the bunch of the large (true) Plantain,—up to 100 or even 200 if grown in very rich soil; the peel is much thinner and the distal beak is proportionately larger. Though this fruit, like all the other "Congos", is a kind of Plantain and frequently marketed as such, the growers seldom confuse the two types—although both may be planted in the same small field.

The plant resists the banana disease very well, and is one of the very best varieties for the small farmer.

Trescientos, Congo Trescientos; this splendid variety is rare. The stem is weak and slender, and therefore very liable to be blown down by winds unless the very heavy bunch is propped up firmly. The small, curved fruits are of first quality.

PLANTAIN. See **Plátano.**

PLUM. See **Ciruela.**

PLUM, NATAL. See **Amatúngulu.**

PLUM, WILD. See **Almendrillo.**

POHA; Husk Tomato, Ground Cherry; *Physalis peruviana* L.

A South American vegetable of considerable importance in many tropical countries, but rarely grown here. The fruit makes an excellent jam or preserve, especially when spiced, and may be pickled.

It is of such rapid growth and easy cultivation that varieties from Hawaii and Mexico should be tried out here with the view to introduce them into general use.

POHA SILVESTRE; *Physalis* spp.

The following species of this interesting genus occur in open grounds especially in abandoned fields near towns, and the fruits of all are quite edible and would probably improve under cultivation: *P. angulata* L.; *P. pubescens* L.; *P. turbinata* Medic.

POMARROSA; **Roseapple**; *Eugenia Jambos* (L.) Millsp.

Second-class introduced fruit tree, 4–10 m. Very common, especially in wetter districts. Seldom actually cultivated; usually occurring in open pastures and along streams, lakes and roadsides; from East Indies originally. Eaten fresh, but also of value as a preserve and jam fruit; like the Malayapple it carries its delightful rose perfume through moderate cooking.

POMARROSA DE MALAYA. See **Ohia.**

POMEGRANATE. See **Granada.**

POMELO. See **Toronja.**

POND-APPLE. See **Corazón Cimarrón.**

POTATO. See **Papa.**

POTATO, SWEET. See **Batata.**

PRICKLY PEAR. See **Tuna Brava.**

PUERRO; **Leek**; *Allium Porrum* L.

A rather rare, onion-like vegetable, occasionally cultivated, 3–6 dm. Of uncertain origin. Two varieties are being tested on the Model Farms.

PUMMELO. See **Toronja.**

PURSLANE. See **Verdolaga.**

QUEEN OF THE NIGHT. See **Reina de la Noche.**

QUENEPA; **Guinep, Spanish Lime**; *Melicocca bijuga* L.

Second-class fruit tree, 5–15.; semi-cultivated throughout Island; probably native. Very popular, though not a nutritious fruit; seed not eaten. Experiments at the By-Products Plant indicate that a good cattle feed may be made from the seeds and skins and a dulce from the pulp. Practically no variation in fruits. Tree has some value as a wind-break species. Not exportable.

QUIMBOMBO. See **Guingambó.**

RABANO; **Radish**; *Raphanus sativus* L.

One of the commonest temperate vegetables; grown mostly for the foreign population. Probably Asian. Many horticultural varieties teseted. One botanical variety (*R. s.* var. *longipinnatus* Bailey), the huge Japanese radish, has succeeded at Trujillo.

RABANO PICANTE O RUSTICO; Horse-Radish; *Armoracia Armoracia* (L.) Cockerell.

This excellent seasoning or relish root has been introduced at the Trujillo Plant Propagation Station; thus far the climate does not seem to inhibit the growth but since it originated in southeast Europe it may not long endure our climate at the sea-coast.

RADISH. See **Rábano.**

RAIN-TREE. See **Ramón.**

RAMON, Ramoncillo, Palo de Ramón; *Trophis racemosa* (L.) Urban.

An indigenous tree of the limestone hills of the lower and middle elevations, 10–15 m. The leaves are occasionally used for forage here. Never cultivated.

RASPBERRY. See **Frambuesa.**

RASPBERRY, PORTO RICAN. See **Zarza.**

REINA DE LA NOCHE; Queen of the Night; *Selenicereus grandiflora* (L.) Britton & Rose.

Cultivated in gardens; stems frequently colored reddish to deep purple. Several meters long, about 3 cm. in diameter; fruit egg-shaped, 8 cm. in length. Should be in all gardens in the dry districts.

REMOLACHA; Beet; *Beta vulgaris* L.

One of the commonest of the "temperate" vegetables; succeeds well in the cooler, moister districts.

Several varieties marketed. Unknown wild, but probably a much changed form of a sea-coast plant of Western Europe. The sugar-beet (*B. vulgaris* var. *saccharifera* Alef.) has succeeded at Trujillo Plant Propagation Station.

RICE. See Arroz.

ROSEAPPLE. See **Pomarrosa.**

RUDA; Rue; *Ruta chalapensis* L.

This strong-smelling garden herb from the Mediterranean region is fairly common throughout the Island.

RUE. See **Ruda.**

RHUBARB. See **Ruibarbo.**

RUIBARBO; Rhubarb; *Rheum Rhaponticum* L.

Practically unknown in cultivation in the interior but growing well at the Plant Propagation Station at Trujillo; this Siberian plant, however, will probably not well endure the hot seasons.

RUTABAGA; *Brassica campestris* L. var. *Napobrassica* DC.

A rare forage vegetable; cultivated only occasionally for stock feed. Succeeds fairly well at Trujillo.

SABORIJA, Tomillo; *Thymus vulgaris* L.

No kitchen-garden here should be without this first-class seasoning herb from Europe; a few leaves cooked with beans, stews, maize dishes, etc., add an appetizing flavor.

SAGE. See **Salvia.**

SALSIFI; **Salsify**; *Tragopogon porrifolius* L.

Apparently recently introduced; succeeds fairly well, especially in the higher elevations such as the Cayey Model Farm; it is being tested at several localities. Native of South Europe.

SALSIFI ESPAÑOL; *Scolymus hispanicus* L.

This rare root crop from Southern Europe is being tested at the Cayey Model Farm.

SALVIA; **Sage**; *Salvia officinalis* L.

For a "temperate" (European) Herb this species behaves very well even at sea-level here. The very distinctive leaves make an excellent tea and should be used more commonly in stews and in seasoning meats. Plants 18 months old at the Trujillo Plant Propagation Station have been in flower for several months and are becoming decidedly woody at the base. Recommended for general cultivation.

SAMAN, Guango; **Rain-tree**; *Samanea Saman* (Wild Merrill.

Naturalized (from Mainland Tropics) long ago; forage tree, 8–20 m. Rarely planted here for forage; testing as a wind-belt species at Vega Baja, Arecibo and Cayey Model Farms. Curved black pods, very nutritious for swine and cattle.

SANDALO DE JARDIN, Yerba Buena; **Mint**; *Mentha nemorosa* Willd.

The delightful odor of its leaves makes this Old-World species welcome in every garden; unfortunately rare here. Naturalized

SANDIA; **Watermelon**; *Citrullus Citrullus* (L.) Karst.

This garden fruit is very difficult to grow here, but small, usually pale-fleshed specimens are sometimes marketed. All the (few) varieties seem very susceptible to fungus and insect attacks. Not worthy of general cultivation here.

SAPOTE BLANCO; **White Sapote**; *Casimiroa edulis* La Llave and *C. tetramera.*

Recently introduced Central American second-class fruit trees, 3–6 cm. Rare; several fruiting trees near Río Piedras show perfect adaptation to our coastal climate, though they are supposed to be sub-tropical and to never succeed in the Tropics below 1,000 m. elevation. Very variable as to fruit characters; there are several named forms (budded California varieties) in the trade.

SAPODILLA. See **Níspero.**

SAPUCAIA; *Lecythis usitata.*

This excellent Amazonian nut-tree has recently been introduced at the U. S. Experiment Station.

SATSUMELO; *Citrus nobilis* var. *Unshiu* X *C. grandis.*

A new hybrid between the Satsuma orange and a grapefruit. Five young seedlings were received in December, 1924, at the Plant Propagation Station at Trujillo from the U. S. Department of Agriculture.

SCORSONERA. See **Escorcionera.**

SEBUCAN; *Cephalocereus Reyeni* (L.) Britton & Rose.

A short-trunk species, branching above, 2–8 m. high, growing on the southern side of the Island. Fruits 5 cm. in diameter, green or reddish, the pulp red, with many small black seeds. Also occurs on the neighboring islands.

SEBUCAN. See **Pitajaya.**

SESAME. See **Ajonjolí.**

SHALLOT. See **Eschalota.**

SHADDOCK. See **Toronja.**

SHEA-BUTTER. See **Manteca de Shea.**

SIAMELO; *Citrus nobilis* (King Orange) X *C. grandis.*

One of the new hybrids between the Mandarin and Pomelo. Two varieties, one with a Shaddock, the other with a Grapefruit parent, were received in December, 1924, at Trujillo Plant Propagation Station.

SILANI; Philippine Cowpea; *Vigna marina* (Brum.) Merrill.

Found here in 1914 at Punta Cangrejos, wild. Introduced (as a new form, probably) from the Philippine Islands (presented by the Bureau of Agriculture) in October, 1924, as a cover and forage crop. Unlike most similar legumes, this species, according to Mr. P. J. Wester, Agricultural Advisor to the Philippine Government, can readily be propagated *from cuttings;* and since the stem reaches

2-3 m. this is very important, especially when planted in loose sandy soils. Seeds too small and too few for use as human food. Being tested (at Arecibo Model Farm and Trujillo Station) as a forage plant.

SINCAMAS; Yam Bean; *Cacara tuberosa* (Lam.) Britton.

Formerly rather commonly cultivated for its turnip-like roots; rare now. Ripe seeds not eaten but young pods may be used. Origin not known. Highly prized in Mexico where the watery, sweet roots are one of the commonest vegetables; eaten both raw and cooked. A brillant white starch can be made from the roots. The plant requires support—tree, fence, etc.—since it may attain a length of 10-15 m.

SONCOYA; *Annona purpurea* Moc. & Sessé.

This second-class fruit tree of Mexico and Guatemala has recently been introduced at the U. S. Experiment Station; the tree is of moderate size, like the other Annonas, and is cultivated to some extent in Mexican an Central American door-yards.

According to Popenoe, the fruit is round, 10-15 cm. in diameter and somewhat resembles the Corazón but its rind is covered with protuberances like those of the Ilama. Of value in the Department's annona breeding work which is just beginning.

SORGHUM. See **Millo.**

SOURSOP. See **Guanábana.**

SPANISH PLUM. See **Quenepa.**

SPINACH. See **Espinaca.**

SPINACH DOCK. See **Espinaca sin aroma.**

SPONGE, VEGETABLE. See **Esponja.**

SQUASH. See **Calabaza.**

STAR-APPLE. See **Caimito.**

STRAWBERRY. See **Fresa.**

SWEET-CORN ROOT. See **Lerén.**

SWEETSOP. See **Anón.**

SUGARAPPLE. See **Anón.**

SUCCORY. See **Achicoria.**

SUNFLOWER. See **Girasol.**

TABASCO. See **Ají Pequeño.**

TAGUA-TAGUA; *Passiflora serrato-digitata* L.

A strong-growing, woody vine occurring in open forests and along river banks at lower and middle elevations of the Island; 3–8 m. Fruit roundish or oblong, 4–5 cm.

TAMARIND. See **Tamarindo.**

TAMARIND, MADAGASCAR. See **Voa-Vanga.**

TAMARINDO; **Tamarind**; *Tamarindus indica* L.

Common naturalized third-class fruit tree, 5–15 meters. Planted, but never cultivated in orchards. Pulp (usually very acid, rarely sweetish) surrounding seeds used for making drinks and a paste with sugar. East Indies. The sugar content of the pulp is about 31 per cent but this intense sweetness is completely disguised by the 12 per cent tartaric acid.

TANGELO; *Citrus nobilis deliciosa* X C. *grandis.*

Several trees of this first-class citrous hybrid have been introduced from the mainland (U. S. Department of Agriculture) during the past 20 years, but probably because of the size of the fruit (8–12 cm.) and the comparative lack of interest in testing out citrous varieties locally, it has not been propagated here. A splendid old specimen, 4–5 m., of the *Sampson* variety is fruiting near Bayamón.

TANGELORIN; *Citrus nobilis deliciosa* X *C. grandis* X *C. nobilis* (form "King").

This double hybrid was received December 24, 1924, from the U. S. Department of Agriculture and is growing at Trujillo Plant Propagation Station. Having the "blood" of both the King and Mandarin blended with the Pomelo, the flavor of the pulp may prove less acid than that of the Tangelo.

TANGERINE. See **Mandarina.**

TARO. See **Culcas.**

TARO. See **Malanga.**

TARO DE HAWAII; *Caladium Colocasia* var. *esculenta* (L.) Schott.

Two high-grade Taros were sent from the Federal Experiment Station at Honolulu, H. T., in 1924 to the Plant Propagation Station at Trujillo. The *Manaa* has yielded a good crop of corms and cormels of the rather rare yellow color. The petioles are pale green with brown-rose bases. This plant appears to stand between the true Taros and the true Dasheens.

The *Hapuu* Taro closely resembles the *Manaa* but its numerous small cormels are white.

TAYOTE. See **Chayote.**

TE; Tea; ***Thea sinensis*** **L.**

Introduced in 1903 by the U. S. Experiment Station at Mayagüe Shrubs here seldom attain over 1 m. (where they *should* reach se eral—up to 9 m.; plants spend their vitality in excessive flowerin with little leafage. Might succeed at Cayey or Utuado. Leaves po sess good strength. A strong old plant (1 m.) is in evidence Villa León, near Bayamón.

TEA. See **TE.**

TEA, PARAGUAY. See **Maté.**

TEMPORANA. See **Nigua.**

TETA DE BURRA. See **Caimitill**

THYME. See **Saborija.**

TI-ES. See **Canistel.**

TOMATE; Tomato; ***Lycopersicon Lycopersicum*** **(L.) Karst.**

This old South American vegetable is not now grown on a lar scale; limited local consumption. On account of the bacterial blig (*Bacillus solanacearum*), which seems to be present in practical every district, it is seldom possible to get a good "stand" of plant although individual plants may produce excellent fruits before su cumbing to the blight. Several standard varieties are grown in small way; the Stone and the Ponderosa are popular. Both t botanical varieties *cerasiforme* Alef. and *pyriforme* Alef. have giv fair results. Fresh imported seed is used; otherwise the varie reverts.

TOMATE DE ARBOL; Tree Tomato; ***Cyphomandra betacea*** **(Cav.) Sendtn.**

This South American fruit vegetable was introduced in 1903, perhaps earlier, and is now well established in the Maricao distri and probably in other places; under cultivation it attains a heig of 3 or 4 m., though it usually begins to bear at 2 m. Apparent no variation, except as regards color and size of fruits; fruit usual oval or oblong, 5–12 cm. long, dull red or purplish, with a slight acid flavor distinctly tomato-like. Is usually cooked but may eaten raw when thoroughly ripe

TOMATO. See **Tomate.**

TOMATO, HUSK. See **I**

TORONJA; Grapefruit, Pomelo. Pummelo, Shaddock; *Citrus grandis* (L.) Osbeck.

This old South Asian species probably reached the Island somewhere about the first or middle of the last century but no interest naturally awakened in the bitter, coarse fruits of those times and it was not until about 1902 that commercial interest was awakened in the named varieties of the so-called "grape fruit."

The U. S. Census Report for 1920 shows 219,000 bearing and 114,000 non-bearing trees. The acreage is estimated at about 4,500. During the past 2 years some 100 acres of unprofitable orchards in the Vega Baja–Manatí section have been uprooted.

In the 1909–10 season the number of boxes exported was 48,441 (valued at $162,749); in 1919–20 the number was 419,629 (valued at $1,332,742); in the 1923–24 season the export was 666,648 boxes (valued at $2,000,000 which was an increase in value of some 44 per cent over the previous season); the 1924–25 season's output is estimated at 690,000 boxes.

About 1920 experiments in canning grapefruit were started here and in the 1921–22 season a beginning was made on a commercial scale. In the 1922–23 season 7 canneries were active and about 75,000 cases of tins worth about $5 per case were put up. From various causes this canning business was not so successful in the 1923–24 season and at present comparatively little is being done. One of the canneries has at last begun to save a portion of the peels and seeds from cutting tables, as recommended by the Division of Agricultural Development, drying them in a special dehydrating apparatus (modeled after those at the By-Products Plant in Mayagüez). This dried and ground peel and seeds will probably hold a place in the cattle feed market here in competition with the imported feed stuffs.

The following varieties are the most popular here:

Duncan. This old Florida favorite has oblate, good-sized fruits, with a moderate amount of seeds and a well flavored juice abundant in a grayish-green pulp. Very popular here.

Ellen. A pink-fleshed variety, originating about 1907 at Oneco, Fla.; flavor excellent; not popular.

Foster. This very intresting variety originated a few years ago at Manavista, Fla., as a "sport" from the Walters; pulp and juice a rose pink or purplish color—sometimes showing through the yellow peel; very early and should become very popular as an "ade" fruit, now that cheap juice extractors are available.

Marsh, Marsh Seedless; ranks with Duncan as the most popular variety here today. A medium-sized sort, with light yellow, very smooth rind; juice abundant with fair flavor: nearly or quite seedless. Originated at Lakeland, Florida, about 1895.

Pink-fleshed; two or three presumably distinct varieties have been introduced here (both in the Mayagüez and north coast districts) but they appear not to be popular here; extended trials should be made. Several varieties of the so-called *Shaddock* race have rose or even *red* pulp; their peel is usually thick and the flesh is likely to be tough and bitter.

Triumph; a fine-appearing fruit, seedy, juicy but rather lacking in flavor.

The *Alamoen* is a peculiar type of Pomelo, introduced in 1924 (at Trujillo Plant Propagation Station) *via* the U. S. Department of Agriculture from Surinam. The fruit is reported as of very superior, distinct, mildly acid flavor. The young branches are *blackish.* Though no wild Citrus species are extant in northern South America, this fruit. of unknown origin, may have to be classed as a "new" quasi-cultigen "mutant".

Bianchi; a strange "mutant", having the flavor of a mild Pomelo, the rough and almost furrowed peel of a Limón de Cabro, and the size of a large Shaddock (12–15 cm ; the leaves smell like those of the sour orange: and the spines are unusually long and numerous. Only one mature tree (in the Añasco Valley) in evidence.

Pernambuco; one of the old Florida varieties of questionable value.

Tresca; a rare Florida variety.

Several forms of the so-called wild, or seedling grapefruit are in evidence; these are usually thick-peeled and bitterish.

Unfortunately most of the growers here have not kept their varieties distinct, wherefore today it is almost impossible to tell anything about a grove tree except as to whether it bears seedless or seedy fruit.

TREBOL; Red Clover; *Trifolium pratense* L.

This Old-World forage crop is very rare and practically worthless here.

TREBOL HUBAM; Hubam Clover; *Melilotus alba* Desr. var. *annua* Coe.

One of the very best of the recently introduced forage crops. With inoculated soil it grows rapidly to 1.5–2 m.; seeds well within 6 months. Is being distributed from Model Farms. Probably as nutritious as alfalfa. Originated in Iowa in 1916.

TREBOL DEL JAPON; Japan Clover; *Lespedeza striata* **Hook. & Arn.**

This Oriental hay and forage legume was tried out at the United States Experiment Station about 1903; it has never succeeded well. Gandul would probably produce 10 times as much forage on the same area.

TREE TOMATO. See **Tomato de Arbol.**

TRIGO; Wheat; *Triticum æstivum* L.

An old and extremely important cultigen of undetermined and probably multiple origin. Introduced at the Toa Grange about 1515, but has never succeeded here as a crop.

TRUMPET-WOOD. See **Llagrumo.**

TUNA BRAVA; Prickly Pear; *Opuntia Dillenii* (Ker Gawl) Haw.

A much branched cactus of the coastal zone, especially on the south side of the Island, also on Mona, Vieques and Icacos; 0.5 to 2 m. high. Fruit pear-shaped, red or purple, edible, 5–8 cm. long.

TUNA BRAVA (Lisa); Semaphore Cactus; *Opuntia rubescens* Salm-Dyck.

This splendid tree-like species occurs wild in the southwestern district of Porto Rico, also on La Mona, Icacos, Vieques and Culebra. A spineless form was introduced in March, 1924, from the Gardens of the Danish Consulate in Charlotte Amalie, St. Thomas, U. S. V. I., the first 200 "pencas" giving only 2 living plants. Another introduction was made from the same source in November, 1924, with better results. Will probably become a first-class forage species on the south coast The peculiar habit of the branches (more or less horizontal) and the peculiar fruits which readily take root and produce new plants, distinguish this species from any other except perhaps a rare species occurring on Desecheo

TUNA BRAVA; Tuna; *Opuntia vulgaris* Mill.

A tall species introduced from South America occasionally planted on the south side of the Island.

TUNA DE ESPAÑA. See **Tuna Mansa.**

TUNA MANSA, Tuna de España; Cochineal Cactus; *Nopalea cochinellifera* (L.) Salm Dyck.

Frequently cultivated, especially on the south coast; 3–4 m.; branches usually spineless or very nearly so. The young branches are seldom used for forage but more commonly for "cataplasmas".

Could be used as in Mexico in soups and stews; the young, half-grown "pencas" cut in small dice or slices, give a mucilaginous character to the liquid in which they are cooked. Fruit red, about 5 cm. in length.

TUNA MANSA; Indian Fig; *Opuntia Ficus-indica* (L.) Mill.

A much-branched species, nearly or quite spineless, 3–5 m. Fruit red or yellow, 5–9 cm. long, cultivated very widely.

TURMERIC. See Jengibrillo.

TUNGULU. See Amatúngulu.

TURNIP. See Nabo.

UMKOLO, Umkokolo; *Dovyalis caffra* Warb.

Second-class fruit tree, 3–7 m.; introduced by the U. S. Experiment Station, Mayagüez, about 1903; from South Africa, used for preserves. Distributing from the Trujillo Plant Propagation Station.

UMKOKOLO. See Umkolo.

UVA; Grape; *Vitis vinifera* L.

Several varieties have been planted here during the Spanish régime; some very large vines are in evidence, especially on the south side of the Island; but the fruiting qualities of the plants leave much to be desired. The leaves are attacked by at least 3 species of fungi and the vitality of the plant is severely weakened thereby especially in the districts of heavy rainfall.

The Río Piedras Experiment Station has brought in a considerable number of the standard-named varieties from the mainland, but since a large percentage of these young plants is obviously doomed to disappear it is, at present, unfair to include them in a list of our food plants.

The principal varieties of this species here are: Málaga, Carman, Muscat, Isabella, Almeria, Zante, Fresno Beauty, Flame Tokay, Thompson Seedless, Black Monukka, Royal, Thomas, La Salle, James Ellen Scott, Amurensis (probably a distinct species).

UVA HIBRIDA; *Vitis hybs.*

The following collection of hybrid-grapes (Munson types) was received in December, 1924, at the Río Piedras Experiment Station from Texas, and it is expected that most if not all will endure our climate:

Champanel.
Bailey.
Lukfata.
R. W. Munson.
Edna.
Fern Munson.
Vitis Champinii (a cultigen).

YAUTIA BLANCA, Yautía Rolliza; White Yautía; *Xanthosoma caracu* **C. Koch & Bouché.**

This is the best of the 15 or more distinct varieties of Yautía* which have been in cultivation here since the beginning of agriculture.†

The Rolliza is widely cultivated throughout Porto Rico but does not appear to be common in Santo Domingo, Jamaica, Cuba, nor in the other islands of the West Indies; however, it was taken over to West Africa, presumably in the slave ships, in the first half of the 19th century, and was carried from that region into the Philippines and probably also into the East Indian islands during the latter half of the said century. The plant is rather above medium size with a distinctly glaucous green color with a few rows of lilac markings on the wings of the petiolar sinus. The cormels are of good size with a white bud at the tip; they cook up more soft than do most varieties of Yautía; they have one rather disadvantageous character,—the deep penetration of the cormels below the central rhizome. The rhizome itself is sometimes eaten but is not nearly so delicate in texture as the cormels, and must be "dried out" well after harvesting before cooking.

The young unopened leaves of this variety are frequently used as a green spinach and in certain special stews and soups ("Callalous") not only here but also in other West Indian Islands. The cormels, or so-called tubers, may be used in a great variety of ways on the table and are some 45 per cent richer in carbohydrates than the Irish potato; the fuel value (calories) per pound is about 529 to 538 in the case of the yautía as against 385 for the Irish potato and 570 for the sweet potato. The starch grain of the yautías is about five times the size of the taro, or malanga, starch grain (one-thousandth to 3-thousandths of a mm.)

YAUTIA CALALU; Callalou; *Xanthosoma hastatum* **Eggers.**

A rare species which was probably indigenous here in pre-Columbian times; recorded (by Eggers in 1879) as both wild in forests and cultivated in the Virgin Island as a "spinach" vegetable like the Belembe. Two or three forms of Callalou were collected in

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* The "Yautias and Taniers of Porto Rico", by O. W Barret; Bull. No. 6, Federal Agricultural Experiment Station, 1925.

This appears to be the first Bulletin written on these crops, which have been considered the oldest.

† The word "Yautía", or, as it was originally written "Yahutía", meant, in the Arawak language "place of (ya') the Hutía (or spiny rat, *Capromys* spp.); the Hutía was formerly very abundant in Tropical America and it fed upon roots as well as fruits. The strange idea of the Arawaks to name one of their principal crops after a place where they were wont to secure the Hutía, is one of the most remarkable cases of the kind in etymology.

Trinidad, British West Indies, in November, 1924, and are now propagating at Trujillo Plant Propagation Station; they may belong properly to this species, but only a careful study of their flowers (if produced at all) can decide the question. They are 2 to 4 times the size of our common Belembe, and appear more worthy of cultivation for their tender spinach-like leaves. As evidenced by the paucity of their flowers, they may have been cultivated longer than the Belembe.

(A so-called Wild Tanier, or Yautía, of every uncertain relationship, apparently a "connecting link" between the callalous and the yautías, was found near a Hindu farmer's garden in the mountains of northern Trinidad; under test at Trujillo Plant Propagation Station.)

YAUTIA DOMINICA; Yautía Samanal; *Xanthosoma sagittæfolium* (L.) Schott.

This excellent (perhaps best of all* as regards the richness of the cormels) rare form is related to the Amarilla, but is larger, has more slender petioles with stripes or spots of purple on the sinus wings, and paler leaf-blades. Except for their over-firmness after cooking, the beautifully colored cormels are ideal, as far as any root can be in the way of concentrated nourishment and keeping qualities.

YAUTIA GUAYAMERA; *Xanthosoma violaceum* Schott.

This, with the Morada, is among the most striking of all cultivated plants. The almost unique color of the petiole and larger veins of the blade—a glaucous blue "bloom" over a violet-black shade—distinguish these two varieties from all others. The cormels are very different from those of the Morada,—pale rose or purplish, and rather slender. The leaf-blade, bent at an acute angle with the stalk, hangs nearly vertical and gives the plant a highly ornamental aspect.

Under various names it has traveled widely and has been for many years a popular ornament in the Botanic Gardens of the Far East.

YAUTIA DE HUEVO. See Yautía Martinica.

YAUTIA ISLEÑA; *Xanthosoma sp.?*

Two forms are known of this rare indigenous variety, and they may prove to be botanically distinct; one from the west end of the Island has the flat leaf-blade of the Mañola and excellent regular-shaped pinkish cormels; and one large (up to 2 m.) dark green form, from the south side, with high-colored cormels which are mealy and purplish when cooked, like those of the Vino.

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* In Heft 71 of Das Pflanzenreich, A. Engler and K. Krause list 39 species and about 20 varieties of *Xanthosoma.*

YAUTIA JAMAICA-TRINIDAD; *Xanthosoma atrovirens* C. Koch & Bouché.

This, the largest of all known true yautías, has been introduced several times from the U. S. Department of Agriculture but thus far is not yet widely cultivated here; at the Trujillo Plant Propagation Station this magnificent variety reaches a height of over 3 m. and in rich moist soil would probably attain 4.5 m.—as tall as the largest Yautía Palma. The petiole is reddish brown toward the base, purplish along the sinus wing, and glaucous blue-green above; the midrib and basal veins are mauve-purple beneath.

The rhizome is orange-yellow inside, and the cormels are distinctly yellowish before and olive or grayish-yellow after cooking; the terminal bud is bright rose; the size is not so large in proportion to the size of the leaf as that of the rolliza, but cormels weighing 0.5 kilo are common.

The best of the introduced varieties, but it requires good soil for its proper development.

A variety having leaf characters similar to this was obtained from Jamaica by the U. S. Department of Agriculture, but its cormels are of a pronounced rose color, and the rhizome is pale rose inside. A similar variety having white-fecula cormels was sent to the U. S. Department of Agriculture from Kamerun, West Africa, about 1905: it probably originated somewhere in Central America.

Another similar sort was obtained from Guatemala; it appeared even more vigorous and perhaps more prolific than the type (which was obviously introduced into Trinidad from Jamaica).

YAUTIA JENGIBRILLA; *Xanthosoma atrovirens* C. Koch & Bouché var. *Kochii* Eng.

A rare indigenous species of uncertain relationship; this particular variety not occurring outside of Porto Rico, it appears. The leaf-blade is flat, like the Manola, but the leaf-stalk is slender and colored, and the cormels are very peculiar in shape—like those of the Arrowroot (whence the name!). This very interesting variety should be preserved; without encouragement by the Government's institutions it will probably soon become extinct (like many other sister forms, presumably).

YAUTIA MANOLA; *Xanthosoma Caracu* C. Koch & Bouché.

An indigenous variety, apparently becoming rare, distinguished by its dwarf size, very flat leaf-blades, short green petioles, and short rough cormels with a yellow or orange fecula. Since it endures dry soils better than any other variety, perhaps, it should be more widely grown.

YAUTIA MARTINICA, Yautía de Huevo; *Xanthosoma sagittæfolium* (L.) Schott (?).

One of the handsomest and largest of all the 50 or more true yautías. In rich moist soil this variety attains a height of 2–2.5 m.; it grows rapidly and matures in 8 to 11 months.

The petioles are the most marked of all yautías; the basal portion is striped and blotched with cream yellow, light and dark green, and the sinus wings inside and outside are splashed with various shades of rose, maroon, and reddish brown.

The cormels are cylindrical, have an unusual number of large roots, and (probably on that account) tend to produce leafy shoots from their terminal buds; because of the latter characteristics this yautía should be harvested as soon as it matures, the texture and flavor of a *growing* cormel being always coarser and less wholesome than a resting one. After cooking, the yellow fecula of the roots turns grayish or olive shade; like those of the Amarilla, the Martinica cormels never cook up soft. The "madres", or rhizomes are used on the table.

This variety not only flowers very frequently but the flowers often show teratological malformations.

YAUTIA MORADA, Yautía Prieta; *Xanthosoma violaceum* Schott.

This deplorably rare but very striking plant probably originated either in Boriquen or in Quisqueya (Hispaniola) tens of centuries ago, since, in the Yautía survey of the world made by the author (1904 to 1908), no proof was obtained of its existence outside of these two islands; the rather closely similar, though botanically distinct, Yautía Guayamera, however, is perhaps the most widely known of all yautías (though it has passed, in its guise as a decorative greenhouse ornamental, under many synonyms in many countries since its baptism in 1853).

The violet-shaded leaves borne upright on blackish petioles are as stricking as those of the Guayamera; the blades are held, however, at a normal angle with the petiole. The cormels are very distinct; short, abruptly pointed at each end, and their firm fecula is pale orange brown instead of rose purple.

This, too, is one of our largest Yautías, in good soil attaining 2–2.5 m.

Recommended highly for general planting—not only as a food plant but as an ornamental.

YAUTIA ORQUETA; *Xanthosoma Caracu* C. Koch & Bouché (?).

One of the rarest endemic yautías, sometimes grown in one or two small areas of the interior of the Island. Belonging to the Amarilla group, but having very distinctive leaves—the palest of all known varieties (nearly white when grown in the shade!), the sinus wing always has a few maroon blotches, however. The cormel is light or dark yellow inside. The plant is weak, dwarf, and liable to fungus attacks. While not recommended for cultivation (except in shaded places) it does have value as an ornamental and on account of its strange color it deserves the respect of horticulturists, representing as it does an almost unknown and nearly extinct type of these, the oldest food plants of the world.*

YAUTIA OTO, **Yautía de Panamá**; *Xanthosoma sp.?*

This strange variety, of uncertain relationship, was introduced in 1904 from the Canal Zone by the Experiment Station at Mayagüez.

The leaf-stalks are reddish, remarkably erect, and have strongly reflexed sinus margins; the basal veins of the blade are less exposed than in most yautías.

The cormels are of a beautiful rose shade.

YAUTIA PALMA; *Xanthosoma Jacquinii* Schott.

This is the largest known species of this very interesting group of plants; in favorable situations it attains a height of 3–5 m. undoubtly indigenous if not endemic. Largely used as a pig feed; the coarse rhizomes, weighing 5–15 k. or more, are boiled. One of the few species (of the 38 *known* Xanthosomas) which does not produce cormels. The nearly cylindrical rhizome grows almost entirely at the top, rising in old specimens to 1.5 m. or more above the ground. Semi-cultivated in coffee plantations—where its cool shade is believed to be beneficial: (the marginal veins of the leaf-blade do "weep", especially after rain in hot weather,—a common habit among Aroids).

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* "Promising Root Crops for the South; Yautías, Taros and Dasheens", by O. W. Barrett, Plant Introducer, Office of Foreign Seed and Plant Introduction, U. S. Department of Agriculture, Washington, D. C; issued Feb. 5, 1910.

This bulletin seems to have been the first attempting the classification, on a more or less technical basis, of not only the Yautías, Taros and Dasheens, but also of the edible Alocasias and Callalous, or Yautías used as a spinach vegetable; the classification was based on the examination of about 100 "numbers" of Yautías and about 50 Taros and Dasheens, all grown under identical conditions in the tropical plant Propagation Houses of the U. S Department of Agriculture, Washington, D. C.

YAUTIA PANAMA. See **Yautía Otó.**

YAUTIA PUNZERA. See **Yautía Vino.**

YAUTIA ROLLIZA. See **Yautía Blanca.**

YAUTIA SAMANAL. See **Yautía Dominica.**

YAUTIA VINO, Yautía Punzera; *Xanthosoma sagittæfolium* (L.) Schott (?).

A rare old variety, so named from the claret-colored cormels which are perhaps the best flavored of all Yautías and also of excellent texture when cooked. The petiole is purplish along the sinus wings; the blade is dark green with light veins.

YERBA BUENA. See **Sándalo de Jardín.**

YERBA BUENA DEL JARDIN; Bergamot Mint, Garden Mint; *Mentha citrata* Ehr.

A fairly common flavoring herb here. Deserves a shady moist corner in every garden. Old World in origin, but now cosmopolitan. Produces stems up to 0.5 m.

YERBA ELEFANTE; Elephant Grass, Napier Grass; *Pennisetum purpureum* Schum.

Recently introduced and rapidly becoming one of the most popular forage grasses in the West Indies; habitat, Africa; 2–4.5. At the Cayey Model Farm a plat attained a height of 4 m. in about 3 months. When cut in a forage-cutter only the butts of the larger stems are refused by cattle and horses; swine chew up the cut portions of the culm but do not swallow much of the bagasse.

Adapts itself to almost any soil, but drought in sand prevents its due development. Propagated by stem cuttings, like cane. Elephant-hay meal may properly become one of the common tropical feeds of the future.

YERBA DE GUATEMALA; Guatemala Grass; *Tripsacum laxum* Nash.

Of recent introduction through the Experiment Station at Mayagüez. In deep moist soil this rank grass about equals Elephant Grass as a heavy producer; it endures several cuttings, the stools gradually spreading till nearly all the space is filled. Propagated by root division and stem (base) cuttings. Not adapted to shallow, hard or dry soils.

YERBA GUINEA; Guinea Grass; *Panicum maximum* Jacq.

This commonest forage of the Island, native of Tropical Africa, is today probably the most widely cultivated grass in the Tropics of both Hemispheres.

Propagated almost entirely by division of the root clumps, small handfuls of the culm bases set into the soil about 2 to 4 m. apart. Seeds freely if clumps are unmolested for 6 months; attains 2–4 m. Regularly pastured, but sometimes cut and sold in bundles; very seldom made into hay here. In rich soil with the proper amount of water this comparatively rich grass may be cut or fed down every 3 months; a yield of 118 tons from 1 acre has been reported. Elephant Grass is superseding this old species in many districts.

The hay can readily be ground and stored in sacks.

Probably brought hither from the Guinea coast by the slave ships, on which it was "used for bedding".

YERBA KIKUYU; Kikuyu Grass; *Pennisetum clandestinum* Chiov.

Recently introduced from East Africa.

A sweet, lush grass, easily propagated (by stem cuttings), but not enduring pasturing so well as expected, according to tests at the Insular Experiment Station.

YERBA DE MELADO; Molasses Grass; *Melinis minutiflora* Beauv.

A South American forage grass of considerable merit for certain conditions, but its popularity seems to be decreasing; 1–1.5 m. A strong odor of molasses is given off by this plant, especially when in flower and in full sunshine.

It has gained some popularity as a tick eradicator, but this quality seems to be largely fanciful.

YERBA MORA, Mata Gallina; Garden Nightshade; *Solanum nigrum* L.

This weed, common in many districts, is sometimes used like a spinach, though by many believed to be poisonous.

One of the most variable species of plants known. Some races produce edible fruits—Sunberry, Wonderberry, Morelle, etc.

YERBA PARA. See **Malojillo.**

YUCA, Casabe; Cassava; *Manihot Manihot* (L.) Cockerell.

Two types of this plant are recognized by the farmers of the island. There is probably no botanical distinction between these types, the *Dulce* and the *Brava*. Here the *Brava* or *Bitter*, variety is used almost entirely for the production of starch, while the *Dulce* or *Sweet* is boiled, baked, and sometimes fried. Grated yuca, slightly pressed to remove a portion of the starch, is used in thickening food and also in the form of thin cakes, partly toasted over a slow fire, to make "tortilla de casave" and "empanada", which are articles of domestic commerce. Special machinery is sometimes used for extracting the starch on a fairly large scale. The following varieties of the *Brava* are recognized:

Pata Paloma. A popular variety for starch. Leaves purplish. Yields well.

Palo Blanco. A green-stemmed, small-growing sort.

Coriana. One of the largest starch yucas. Leaves purplish beneath.

Blanquilla. Purple stems and petioles. White root.

Several other varieties, under many names, are known. Some 6 or 8 varieties were introduced from Jamaica in 1903.

The following varieties of *Dulce* are more or less common throughout the Island:

Ceiba. A large, strong-growing white sort.

Coriana. Resembles the *Coriana Brava,* but has greener stems and leaves.

Mameya, or *Seda.* An excellent table root with yellowish, rich fecula.

Pana. The best table sort. Purple petioles.

A yellow-fecula variety from Trinidad was introduced in November, 1924, and is propagating. Several yellow varieties, were introduced from Colombia *via* the U. S. Department of Agriculture at the Mayagüez Experiment Station. Seedling varieties have never been properly tested here, although seeds are readily produced in vigorous plants, 10–15 months old.

YUQUILLA, Maranta; Arrowroot; *Maranta arundinacea* L.

Originally from South America, this once very widely cultivated root-crop is now rarely grown here. No variations (except the white-variegated form) known here.

As in the case of the Maraca, the strong longitudinal fibers preclude using it on the table. The readiness with which the large starch grain is removed from the fecula, however, makes it a favorite with the small farmer who prefers to grow his own starch.

Propagated from the white, scaly, tuberous rootstocks.

ZANAHORIA; Carrot; *Daucus Carota* L.

The cultivated variety (*sactiva* DC.) of this old root-crop native to Europe, North Africa and Asia, is one of the commonest vegetables here. When quickly grown the roots are of good flavor without fiber and with no bitterness. It is in the markets practically every day of the year. Only comparatively few varieties are in evidence. Some large varieties have been tested at the Model Farms and the Trujillo Plant Propagation Station as cattle forage.

ZARZA; Porto Rican Raspberry; ***Rubus florulentus*** **Focke.**

Wild species found, according to Britton & Wilson ("Scientific Survey of Porto Rico and the Virgin Islands") in the mountain forests of Maricao and Adjuntas. Since this species attains a length of 10 m. it may prove of value as a parent.

ZARZA. See **Frambuesa Común.**

ZARZAMORA COMUN; Common Blackberry; ***Rubus argutus*** **Link.**

Recently introduced by the Insular Experiment Station; a very prickly plant, 1 m.; may succeed in the higher elevations.

ZARZAMORAS MISCELANEAS; Miscellaneous Blackberries.

The 3 following species have been introduced at the Insular Experiment Station:

Rubus cuneifolius Pursh. Sand Blackberry.
Rubus procerus Muell. Himalaya Blackberry.
Rubus loganobaccus Bailey. Loganberry, Calif.

Some of these Rubi, it is believed, will eventually not only supply the great lack of these fine fruits here but may be exported.

Some have begun fruiting at Cayey and San Sebastián Model Farms.

ADDENDA

The following species of "Citrus relatives" were received during August, 1925, from the U. S. Department of Agriculture:

AMONTAY; *Citrus hystrix* DC. var.

One of the best of the many varieties of this species.

CIDRA OLOROSA; **Perfume Citron**; *Citrus medica odorata.*

Probably from S. China. Introduced at Villa León several years ago, but lost.

CHINA CLEMENTIN; **Clementine Orange**; *Citrus* hyb. (?)

Supposed to be a hybrid between the Naranja and a Mandarin known as "Dancy Tangerine".

DELANDAN; *Citrus* sp.

A rare fruit from the Philippines.

ETROG; *Citrus medica* L. var.

This rare variety of citron is used ceremonially by the Jews. The fragant fruits bring high prices.

ISKALAN; *Citrus* sp.

One of the least known of the Oriental citrus fruits.

KABAYAO; *Citrus (Papeda) hystrix* DC.

An old Philippine species. Pulp cells contain oil.

KAVISTA BATU; *Feroniella lucida* Sw.

From Java. Fruit roundish, 4–6 cm.

KUMQUAT DE AUSTRALIA; **Finger Lime**; *Microcitrus australasica* (F. Muell.) Swg.

From Queensland. Fruit edible. Drought resistant.

KUMQUAT DE HONGKONG; **Hongkong Wild Kumquat**; *Fortunella hindsii* (Oliv.) Swg.

From Hongkong. Fruit roundish, reddish.

LEMONQUAT; *Citrus* hyb.

A hybrid between the Kumquat and the Lemon.

LIMON DE CHINA; **Chinese Box Lime**; *Severinia buxifolia* (Oiv.) Ten.

A spiny shrub from South China. Fruit black.

LIMON DE DAVAO; **Davao Lemon**; *Citrus* sp.

This Lemon-like fruit comes from S. E. Mindanao, P. I.

LIMON DE GABON; **Poir-a-poudre**; *Balsamocitrus gabonensis* Sw.

From W. Cent. Africa; of value in breeding work.

LIMON DE INDO-CHINA; *Atlantia citrooides* Pierre.

Small tree from Indo-China. Fruit orange-like, 2 cm.

LIMON DE SUDAN; *Citropsis Schweinfurthii* (Engl.) Sw. & M. Kellerman.

A very rare "citrus relative" from the Sudan. Fruit lime-like, 3 cm. in diam., with a *sweet* pulp.

MAMIS; **Philippine Mandarin**; *Citrus nobilis* var.

The old Philippine Mandarin is one of the largest and best. Peel green. Comes true to seed.

ORANGEQUAT; *Citrus* hyb.

Another new hybrid between China and Kumquat.

TABOG; *Chætospermum glutinosa* (Merrill) Swg.

From Luzon, P. I. Fruit 5–8 cm. in diameter.

TALAMISAN, **Tamisan**; *Citrus longispina* Wes.

First-class fruit tree, 5 m., from the Philippine Ids. Fruit 6 cm., very juicy.

TANGELOLO; *Citrus* hyb.

Hybrid between the Sampson Tangelo and a Grapefruit seedling.

TANGELOS; *Citrus* hyb.

Besides the already noted Sampson, the Thornton and Williams varieties are now in evidence.

TORONJA DE CHINA; **Chinese Pummelo**; *Citrus grandis* (L.) Osbeck.

A Chinese variety of the Oriental Grapefruit, or Pumelo.

WOOD-APPLE; *Feronia Limonia* (L.) Swg.

Oriental fruit tree. Fruit 6–9 cm., edible

The following species were inadvertently omitted from previous text:

APRIN; undetermined species.

A rare fruit grown in Vieques; tree medium-sized, fruit 2–4 cm. n diameter, green; pulp more or less sour.

BAEL; **Bael Fruit**; *Belou Marmelos* (L.) (W. F. Wright) Correa.

Third-class fruit tree from North India. Introduced in 1913 at Villa León, Bayamón.

IGNAY; *Antidesma bunius* Spr.

Second-class fruit-tree from Philippine Ids., recently introduced ear Bayamón.

ABOLO; *Diospyros discolor* Ww.

Second-class Philippine fruit tree, introduced about 1910 at the ederal Experiment Station.

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Dioscorea rotundata Poir. ÑAME GUINEA.
Dioscorea trifida L. f. ÑAME MAPUEY.
Diospyros Kaki L. KAKI.
Ditremexa occidentalis (L.) Britton & Rose. HEDIONDA.
Dolichos Lablab L. CHÍCHAROS.
Dovyalis caffra Warb. UMKOLO.

Dovyalis hebecarpa Warb. KETEMBILLA.
Drypetes lateriflora (Sw.) Krug & Urban. CIRUELA DE GUIANA
Durio zibethinus L. DURIÁN.

Elæis guineensis Jacq. PALMA DE ACEITE.
Eriobotrya japonica Lindl. LOQUAT.
Eryngium fœtidum L. CULANTRO DEL MONTE.
Erythrina Berteroana Urban. BÚCARE.
Erythrina Pœppigiana (Walp.) O. F. Cook. BÚCARE.
Ervum Lens L. LENTEJAS.
Eugenia æruginia DC. GUASAVARA.
Eugenia axillaris (Sw.) Willd. MURTA.
Eugenia Dombeyana Skeels. GRUMICHAMA.
Eugenia floribunda West. MURTA.
Eugenia Jambos L. POMARROSA.
Eugenia ligustrina (Sw.) Willd. MURTA (PALO DE).
Eugenia monticola (Sw.) DC. BIRIJI.
Eugenia pseudopsidium Jacq. GUAYABA SILVESTRE.
Eugenia uniflora L. CEREZA DE SURINAM.
Euphorbia Longata Leur. LONGAN.

Feijoa Sellowiana Berg. FEIJOA.
Ficus Carica L. HIGO.
Flacourtia cataphracta Roxb. CIRUELA DE LA CHINA.
Flacourtia Ramontchi L'Her. CIRUELA DE MADAGASCAR
Fœniculum Fœniculum (L.) Karst HINOJO.
Fortunella japonica (Thumb.) Swingle. KUMQUAT REDONDO.
Fortunella margarita (Lour.) Swingle. KUMQUAT LARGO.
Fragaria chiloensis Duchesne. FRESA.

Garcinia Benthami Pierre. BUNAG.
Garcinia binucao Gv. BINUKAO.
Garcinia indica L. Choisy. KOKAM.
Garcinia Mangostana L. MANGOSTAN.
Garcinia spicata Hook. f. GARCINIA ESPINOSA.
Garcinia tinctoria (DC.) Dawn. GARCINIA.
Genipa americana L. JAGUA.
Gmelina arborea Roxb. CIRUELA DE MALAYA.
Gossypium barbadense L. ALGODÓN DE BARBADOS.
Gossypium brasiliense Macfad. ALGODÓN DE RIÑÓN.
Gossypium hirsutum L. ALGODÓN DE SILVESTRE.
Gossypium peruvianum Cav. ALGODÓN DEL PERÚ.
Gossypium purpurascens Poir. ALGODÓN DE PUERTO RICO.
Grias cauliflora L. PERA DE ANCHOA.
Gulielma utilis Oersted. PEJIBAYE.

Harrisia portoricensis Britton. PITAJAYA AMARILLA.
Helianthus annuus L. GIRASOL.
Helianthus tuberosus L. ALCACHOFA.
Hicoria Pecan (Marsh.) Britton. PECAN.

Pereskia grandiflora Haw. Hortensia.
Pereskia Pereskia (L.) Karst. Hortensia de Bejuco.
Persea Schiedeana Neis. Coyo.
Persea drymifolia Cham. & Schlecht. Aguacate de México.
Persea drymifolia X Persea Persea. Aguacate Híbrido.
Persea Persea (L.) Cockerell. Aguacate.
Persea sp. Aguacate de Caracas.
Phaseolus aureus Roxb. Mung.
Phaseolus lunatus L. Haba de Sieva.
Phaseolus multiflorus Willd. Habichuela Galana.
Phaseolus vulgaris L. Habichuela.
Phœnix dactylifera L. Palma de Dátil.
Phyllanthus Emblica L. Nelli.
Physalis angulata L. Poha Silvestre.
Physalis peruviana L. Poha.
Physalis pubescens L. Poha Silvestre.
Physalis turbinata Medic. Poha Silvestre.
Pimenta Pimenta (L.) Cockerell. Pimienta.
Pimpinella Anisum L. Anis.
Piper incurvum Sieber. Pimiento Largo.
Piper nigrum L. Pimiento Largo.
Pistacia chinensis Bunge. Pistachio.
Pisum sativum L. Petit-Pois.
Pithecolobium dulce (Roxb.) Benth. Camanchile.
Portulaca oleracea L. Verdolaga.
Prosopis juliflora (Sw.) DC. Mesquite.
Psidium cattleianum Sabine. Guayaba de Fresas.
Psidium Guajava L. Guayaba.
Pueraria hirsuta Schneid. Kudzu.
Punica Granatum L. Granada.
Pyrus communis L. Pera.
Rajania cordata L. Ñame Guayabo.
Raphanus sativus L. Rábano.
Rheedia edulis Planch. & Triana. Ciruela del Monte.

Rheedia madruno (H. B. K.) Tr. & Pl. Madroño.
Rheum Rhaponticum L. Ruibarbo.
Rhodomyrtus tomentosa Wight. Mirto Peludo.
Rollinia mucosa (Jacq.) Baill. Cachimán.
Rollinia sp. Biriba.
Roystonea borinquena O. F. Cook. Palma de Yagua.
Roystonea regia (H. B. K.) O. F. Cook. Palma de Yagua de Cuba.
Rubus adenophorus Rolfe. Frambuesa.
Rubus argutus Link. Zarzamora Común.
Rubus chiloensis Duchesne. Fresa.
Rubus coreanus. Frambuesa.
Rubus cuneifolius Pursh. Zarzamora.
Rubus ellipticus Smith. Frambuesa Amarilla.
Rubus florulentus Focke. Zarza.
Rubus fructuosus. Frambuesa.

Rubus glaucus Benth. Frambuesa de los Andes.
Rubus glomeratus. Frambuesa.
Rubus hawaiiensis. Frambuesa de Hawaii.
Rubus idæus L. Frambuesa Americana.
Rubus innominatus S. Mone. Frambuesa.
Rubus lasiostylus Focke. Frambuesa.
Rubus loganobaceus Bailey. Frambuesa.
Rubus Macrei. Frambuesa Akala.
Rubus melonasius. Frambuesa.
Rubus moluccanus L. var. Fairholmianus. Frambuesa.
Rubus moluccanus L. var. macrocarpus. Frambuesa.
Rubus niveus Thunb. Frambuesa de Nieve.
Rubus occidentalis L. Frambuesa Negra.
Rubus probus Bailey. Frambuesa de Queensland.
Rubus procerus Muell. Frambuesa.
Rubus rosæfolius Smith. Frambuesa Común.
Rubus Thunbergii Frank. Frambuesa.
Rubus trivialis Michx. Frambuesa.
Rubus sp. Frambuesa de Australia.

Saccharum officinarum L. Caña de Azúcar.
Salvia officinalis L. Salvia.
Samanea Saman (Willd.) Merrill. Saman.
Sapota Achras Mill. Níspero.
Scolymus hispanica L. Salsifi Español.
Scorzonera hispanica L. Escorcionera.
Sechium edule (Jacq.) Swartz. Chayote.
Selenicereus grandiflora (L.) Britton & Rose. Reina de la Noche.
Sesamum orientale L. Ajonjolí.
Sicana odorifera (Vell.) Nand. Pepino Angolo.
Sideroxylon fœtidissum (Jacq.). Ausubo.
Sisymbrium Nasturtium-aquaticum L. Berros.
Soja Max (L.) Piper. Habichuela Soya.
Solanum Melongena L. Berenjena.
Solanum nigrum L. Yerba Mora.
Solanum tuberosum L. Papa.
Spinacia oleracea L. Espinaca.
Spondias cirouella (Bl.) Tussac. Jobillo.
Spondias dulcis Frost. Jobo de la India.
Spondias Mombin L. Jobo.
Spondias purpurea L. Ciruela.
Stachys Sieboldi Miq. Alcachofa del Japón.
Stenotaphrum secundatum (Walt.) Kuntze. Grama Blanca.
Stizilobium Deeringianum Bort. Habichuela Aterciopelada.
Syzygium jambolana (Lam.) DC. Jambolana.

Tamarindus indica L. Tamarindo.
Teramnus uncinatus (L.) Sw. Cresta de Gallo Blanco.
Terminalia catappa L. Almendro.
Tetragonia expansa Mun. Espinaca de Nueva Zelandia.

Thea sinensis L. Té.
Theobroma cacao L. Cacao.
Theobroma pentagona Ber. Cacao de Nicaragua.
Theobroma bicolor H. & B. Cacao Wariba.
Thymus vulgaris L. Saborija.
Tournefortia hirsutissima L. Nigua del Monte.
Tradescantia elongata G. F. W. Meyer. Coítre.
Tradescantia geniculata Jacq. Coítre.
Tragopogon porrifolius L. Salsifí.
Trifolium pratense L. Trébol.
Triphasia trifolia (Bourm. f.) P. Wilson. Chinita.
Tripsacum laxum Nash. Yerba de Guatemala.
Triticum æstivum L. Trigo.
Tropeolum majus L. Jacinto.
Trophis racemosa (L.) Urban. Ramón.
Typha angustifolia L. Enea.

Vangueria madagascariensis Gm. Voa-Vanga.
Vanilla planifolia Andr. Vainilla.
Vigna marina (Brum.) Merrill. Silani.
Vigna unguiculata (L.) Wolf. Fríjol.
Vitis rotundifolia Michx. Uva Moscadina.
Vitis tiliæfolia H. & B. Pana.
Vitis vinifera L. Uva.
Vitis hybs. Uva Híbrida.

Xanthosoma atrovirens C. Koch & Bouché var. Kochii Eng. Yautía Jamaica Trinidad.
Xanthosoma brasiliense (Desf.) Engl. Yautía Belembe.
Xanthosoma caracu C. Koch & Bouché. Yautía Blanca, Manola, Orqueta.
Xanthosoma hastatum Eggers. Yautía Calalu.
Xanthosoma helleborifolium (Jacq.) Schott. Yautía Belembe Silvestre.
Xanthosoma Jacquinii Schott. Yautía Palma.
Xanthosoma sagittæfolium (L.) Schott. Yautía Dominica, Vino, Martinica.
Xanthosoma violaceum Schott. Yautía Guayamera.
Xanthosoma sp. Yautía Isleña, Otó.

Zamia latifoliata. Marunguey.
Zamia media Jacq. Marunguey del Interior.
Zamia portoricensis Urb. Marunguey de Guánica.
Zea Mays L. Maíz.
Zea Mays var. rugosa Bonaf. Maíz Dulce.
Zingiber Zingiber (L.) Karst. Jengibre.
Ziziphus mauritiana Lam. Jujuba.
Ziziphus jujuba L. Jujuba.

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THE BH 10(12) AND SC 12(4) CANES

SOME OBSERVATIONS ON THESE TWO PROMISING VARIETIES IN THE WEST INDIES

By

ARTHUR H. ROSENFELD
Special Technologist for Cane

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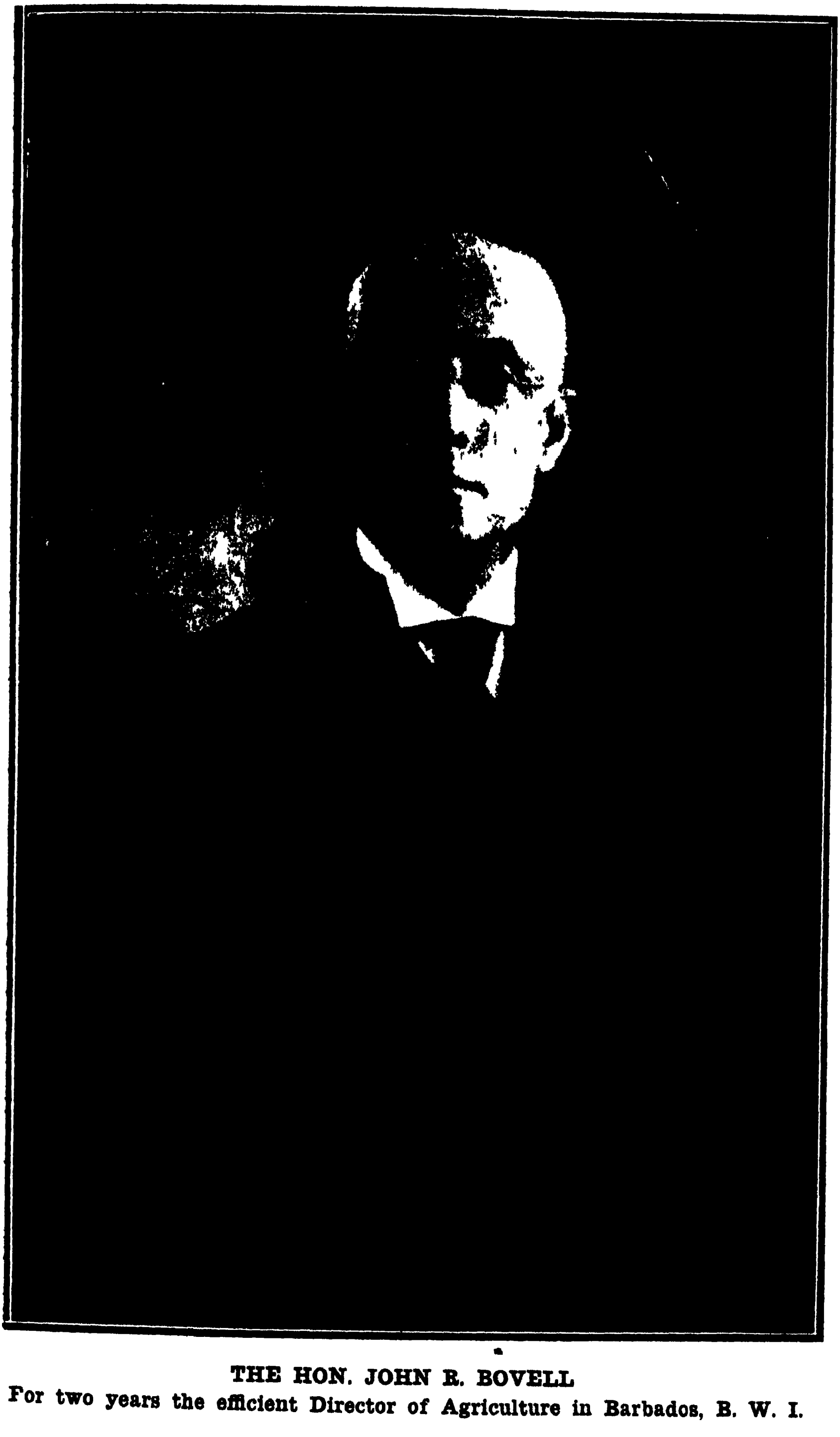
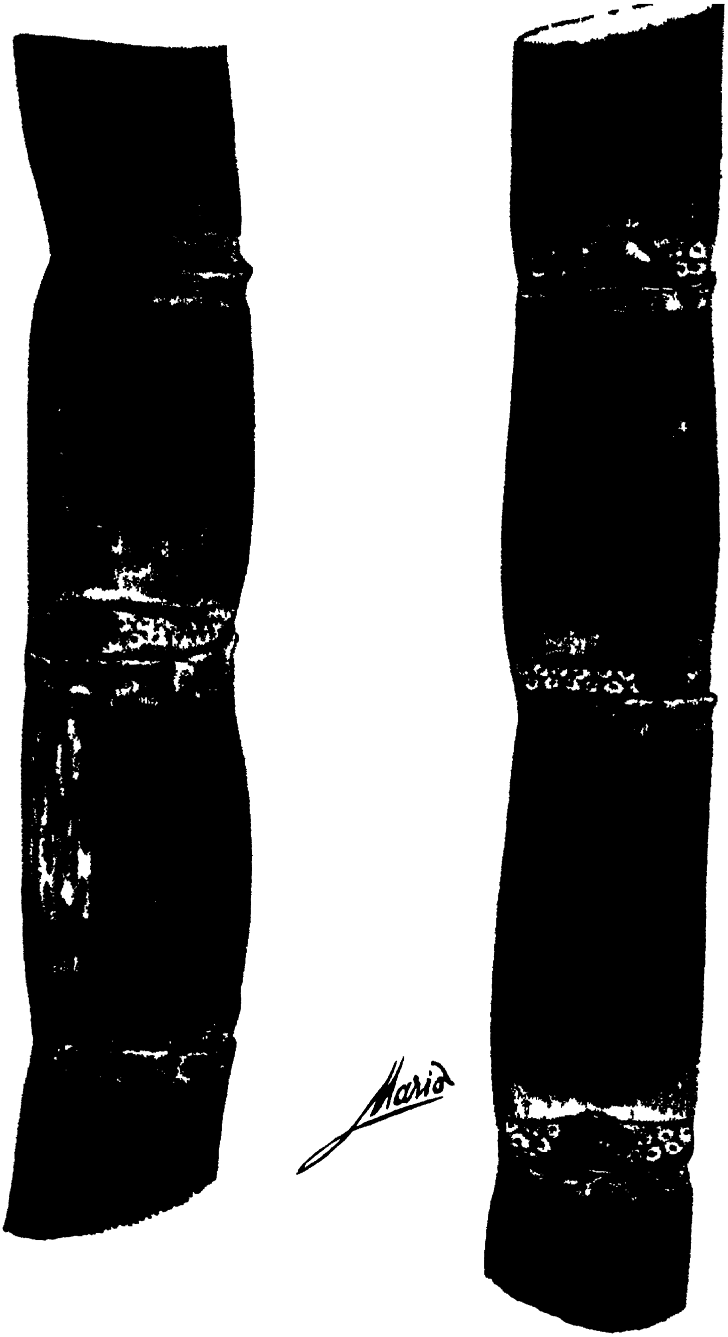
DEDICATION

To that most excellent gentleman, assiduous scholar, practical scientist and father of sugar-cane seedling production, Hon. John R. Bovell, to whom are due so many of the most promising seedling varieties today employed in the world's cane-sugar industry, this little study of two of his productions which have largely contributed to the prosperity of "The Isle of Enchantment" is most respectfully and admiringly dedicated.



THE HON. JOHN R. BOVELL

For two years the efficient Director of Agriculture in Barbados, B. W. I.



BARBADOS HYBRID 10 (12)

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THE BH 10(12) AND SC 12(4) CANES[1]

SOME OBSERVATIONS ON THESE TWO PROMISING VARIETIES IN THE WEST INDIES

By ARTHUR H. ROSENFELD,
Special Technologist for Cane, Insular Experiment Station

Without any question of doubt, the *Barbados Hybrid 10(12)* and *St. Croix 12(4)* varieties[2] of sugar cane are today by far the two most popular canes on the Island of Porto Rico, where they are rapidly replacing even the standard *Cristalina* in the parts of the Island where it has been most strongly entrenched for generations. The Insular Experiment Station receives weekly so many requests for information about and seed of these two varieties that it has appeared advisable to the writer to publish, in easily available form, descriptions of these canes, something of their history in their place of origin and other countries in the West Indies to which they have been imported and a survey of their behavior to date and future possibilities in various parts of Porto Rico

BH 10(12) IN THE BRITISH WEST INDIES

Mr. F. S. Earle, to whom Porto Rico and the sugar world is indebted for detailed technical descriptions of so many cane varieties, gives in his monumental "Sugar Cane Varieties of Porto Rico" (8)[3] the following very accurate description of this variety:

"Erect, or at length somewhat declined, vigorous, a strong stooler, seldom arrows. Stalks long, medium to medium slender, greenish but soon flushing to a uniform dull pink, marked with lines, often blotched, considerable bloom. Internodes medium length, staggered, somewhat compressed, larger below and shouldered on side opposite bud. Nodes constricted, oblique; growth ring rather broad but indistinct, enlarged on the shoulder behind; root band oblique 6 to 10 mm., concolorous but paler, tapering downward, rudimentary roots small, purplish, in 3 or 4 rows; leaf scar glabrous, appressed behind; glaucous band slightly constricted, about 8 mm., somewhat obscured by the bloom of the internode. Buds nearly orbicular, 10 to 11 × 10 to 11 mm., only slightly exceeding growth ring, margin narrow, uniform, often purplish, germination subapical, basal placs, and sparse marginal and apical vestiture. Leaf sheaths with a sparse vestiture of short appressed hairs, green or a little tinted, somewhat glaucous; throat narrow, lannate with a sparse marginal vestiture of long hairs; collar narrow, scarcely reaching the midrib, glaucous; ligule, about 3 mm., margin undulate, not fimbriate; ligular processes small and poorly developed or none. Leaf blades, suberect, the tips declined, flat, about 6 cm., widest above the middle, light green, minutely serrulate, the base even, not ciliate.''

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[1] Paper read at the meeting of the "Association of Sugar Technologists of Porto Rico", held July 5, 1925, at San Juan, P. R.

[2] Many cane breeders indicate year of production, as in case of these two seedlings, by the final figures of the year, without century indication, and the serial number of the seedling produced in that year by a number in parenthesis.

[3] Numbers in parentheses refer to list of literature consulted

This is one of the series of artificial hybrids produced from the same parent as was *SC 12/4—B 6835*—in 1910 in the Island of Barbados, B. W. I., by Mr. Jno. R. Bovell, one of the ''grand old men'' of sugar-cane breeding and one of the three original discoverers of the fertility of cane seed. Two hundred and sixteen artificial hybrids were produced by Bovell in that year and the carefulness and rigor with which these new canes are selected is shown by the fact that in 1916 Bovell (1) reports that only eleven were under experimental cultivation and by 1919 these had been reduced to two ''Of these eleven, one, the BH 10(12), is a very promising variety, and one likely, judging from results so far obtained, to surpass the B-6450 in yield of saccharose per acre. The other ten, altho giving better results than the White Transparent, are exceeded in yield by the B-6450.''

In Table I are summarized results from various tests of the *BH 10(12)* in comparison with other varieties obtained from 1914-16 by Bovell and d'Albuquerque in Barbados (1). Comparisons have been selected with the *White Transparent* of Barbados, which corresponds to our *Cristalina*, which may be regarded as the standard of the Island in most of the experiments with other varieties carried on to date. Any variety which can give more favorable results than the old reliable *Cristalina* under the desirable conditions required by this cane must be a splendid cane of high agricultural and manufacturing yield, good germinating, stooling and ratooning qualities and an excellent keeper.

TABLE I

Condensed Comparative Results in Barbados

Variety	Tons cane per acre	Normal Juice					Lbs Suc. per acre
		Suc	Gluc	S N S	Purity	Glucose Ratio	
I. Plant Canes on Coverly Plantation Memba Field							
W. Transparent	30 67	2 09	086	171	88 92	4 13	8 829
B H 10 (12)	36 83	2 56	060	180	90.77	2 57	11,539
II Plant Canes on Waterford Plantation Tennant Field							
W Transparent	43 08	2 01	058	128	91 55	2 88	11,417
B H 10 (12)	52 54	2 25	052	131	92 88	2 30	15 534
III. Plant Canes on Dodds Plantation—Upper Chapel Field							
W. Transparent	26 14	1 94	086	204	87 00	4.43	6 852
B H 10 (12)	17 57	2 37	046	.154	92 22	1 94	14 879
IV Mean Results for Three Seasons on Dodds Plantation—Upper Chapel Cat Hole Fields							
W Transparent	25.08	2 03	074	. ....	88 86	3 70	6 843
B H 10 (12)..	39 31	2 33	073	.. .	91 17	3 13	12,265
V Duplicate Fields on Coverly and Waterford Plantations—Four Experiments							
W Transparent	35 87	2 05	07[illegible]	.	90 23	3 50	10 123
B H 10 (12)	41 68	2 30	056		91 58	2 44	13 536

These results show us that in five distinct sets of experiments on as many types of soil the *BH 10(12)* has uniformly led the *Cristalina* in tons of cane and sugar produced per acre and was uniformly lower in number of rotten canes per acre at harvest. All chemical analyses showed a higher sucrose in the juice and lower glucose and, hence, superior purities in every case for the *BH 10(12)*.

These results are but typical of the hundreds that have been obtained of late years in Barbados and which have made the *BH 10(12)* the standard variety of that island and of the neighboring island of Trinidad (19).

In this connection the writer wishes to call the attention of the Porto Rican planters to the reports on comparative experiments made with varieties of which the figures given in Table I are an example for Barbados. By obtaining reports from various districts of tests made with new canes in comparison with some such standard cane as the *Cristalina* year after year, it becomes a comparatively

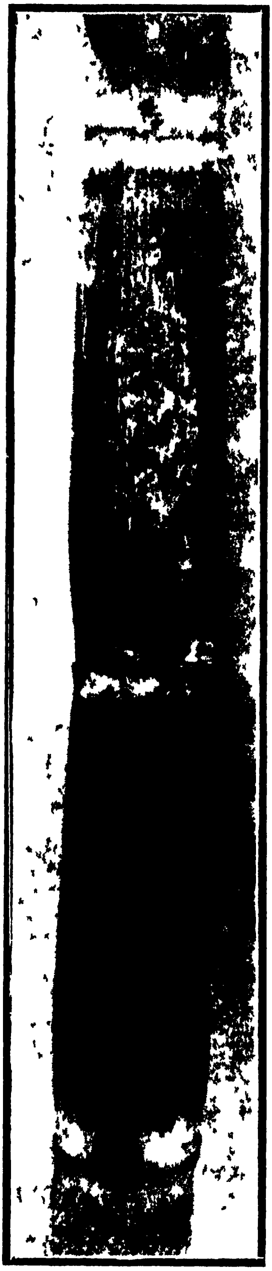

FIG. 1—BH 10(12)

simple thing for the Experiment Station to accumulate data to strengthen and widen out its proper observations in the main Station and substations. Each planter, therefore, making such reports, helps not only his own particular district with his observations, but furnishes information of value—either positive or negative—to other districts as well. Were our Porto Rican planters in various sections of the Island to try out the new varieties furnished them in some such way as is done in Barbados, furnishing the Insular Experiment Station with some such concise and valuable figures as are obtained in our little British neighbor, the task of passing an opinion on the many varieties of cane under trial here at the Station would be very much simplified and be made, also, of much more general application It must be remembered that the conditions at the Station are those of but a very reduced part of this extremely varied Island and that carefully controlled experiments from many districts are worth far more than a few trials under one single set of conditions

Despite the large amount of *BH 10(12)* and *SC 12(4)* today cultivated in Porto Rico, it was an extremely difficult task to obtain even the meagre amount of information on comparative experiments over the Island which we are publishing in this paper, whereas, were a system followed of reporting results of varietal experiments from every district, such as is absolutely general amongst the planters of Java or Hawaii, the Experiment Station could serve as a clearing house for definite information of untold value to all of our planters. The Experiment Station will be more than pleased to arrange such trial plats with the most promising canes in various districts with any planters desiring to do so. It is our policy to try out in such plats only those varieties which have already proven to be of promise here at the Station and, as the planter receives all the cane produced, merely furnishing us—and his brother planters—with the information obtained therein, there is no expense or loss to him through conducting such trials.

The *BH 10(12)*, on the strength of its splendid results in Barbados, was early introduced into the British Colony of Demerara and has given very good results there, but the planters of that colony seem wedded to the cultivation of *D-625*, which in 1924 was grown on 37,108 British acres, or 70.4 per cent of the cane area of the Colony, against 295 acres, or *six-tenths of one percent* of the cane area, for the *BH 10(12)* (10). This is rather difficult for the outsider to understand in view of the following figures on the crop of 1923, representing the average yields in tons of commercial sugar per acre of the *D-625* and *BH 10(12)*, as deduced from the returns supplied by the Managers:

TABLE II

Comparative Results from General Plantings of D-625 and BH 10(12) in British Guiana from Returns Supplied by Managers

	D-625	B H 10(12)
Mean of all plantations	1.80	2.06
Maximum reported	2.85	3.04
Minimum reported	0.28	1.21

Experiments with BH 10(12) appear to have commenced in the British Island of Antigua about 1918 and comparisons with their *White Transparent* (our *Cristalina*) seem to have shown up uniformly in favor of the Barbados hybrid. Table III is a summary of these comparative results for 1919–20 with both plants and ratoon canes (26).

TABLE III

Average Results for Plant and Stubble Crops in Antigua, B. W. I.

Age	Variety	Tons cane per acre	Gallons juice per acre	Lbs Sucrose in juice per acre
Plant	White Transparent	14.78	1100	3000
Plant	B. H. 10 (12)	17.32	1640	3800
Ratoons	White Transparent	10.83	1040	2280
Ratoons	B. H. 10 (12)	11.13	1210	2910

Experiments were started in the neighboring British island of St. Kitts at more or less the same time as in Antigua and in 1921

Collens wrote (26): "BH 10(12) is noted for the high sucrose content of its juice, the average for the present year being 2.31 pounds per gallon. It has headed the list this year in the St. Kitts experiments." Table IV gives in similar form to Table III a summary of the comparative results with plant in 1919–20 and with stubble in figures of means for all seasons:

TABLE IV

Average Results for Plant and Stubble Crops on St. Kitts, B. W. I.

Age	Variety	Tons cane per acre	Gallons juice per acre	Lbs sucrose in juice per acre
Plant	White Transparent	21.0	2560	5350
Plant	B H 10 (12)	26.9	2950	6600
Ratoons	White Transparent			4910
Ratoons	B H 10 (12)			9170

The average ratoon showing of the *BH 10(12)* is particularly remarkable, Watts and Collens (26) remarking:

> "The first place in the list of ratoons is taken by BH 10(12) with the high tonnage of 35.9 tons canes and 9,600 pounds sucrose per acre. . . . . This cane seems likely to prove a good ratooner with a high sucrose content, and especially in the wet districts."

Just off of St. Kitts lies the little island of Nevis, on which the same varieties were tried out as those on St. Kitts. Table V gives a summary of these results in terms of means for each variety grown in 1919–20 as plant canes and as means for all seasons as plant canes, as regards the *BH 10(12)* and *White Transparent*. The weather conditions were against these experiments as a whole.

TABLE V

Average Results for Plant Cane in 1919–20 and as Mean for All Seasons on Island of Nevis, B. W. I.

Season	Variety	Tons cane per acre	Gallons juice per acre	Lbs sucrose in juice per acre
1919–20	White Transparent	19.0	1810	3570
	B H 10 (12)	21.0	2110	1490
Mean of all	White Transparent			4000
	B H 10 (12)			5360

There is still one of these small British islands where interesting results have been secured with *BH 10(12)*—Montserrat. Very little cane had been grown on this island for many years until the high prices during and just after the Great War brought about a revival

Mario.

of the industry. Sugar-cane experiments were then inaugurated by the Imperial Department of Agriculture for the West Indies on similar lines to those conducted in St. Kitts, Nevis and Antigua already discussed above. A series of experiments, consisting of 22 varieties, was planted in 1919 at Farrells Estate, the mill juices from these canes at crop being analyzed at the Government Laboratory, Antigua. The soil on which the experiments were made is a medium clay one, the canes were planted on 6th January, 1919, and the harvest of the plant cane made on 31st March, 1920, being almost fifteen months old at time of harvest. The ratoon plats, which had been previously reaped as plant canes on 28th March, 1919, were now cut as ratoons on 1st April, 1920 No manure was applied to any of these plats, but the land did carry a green dressing of *gandules* during 1918. The rainfall for the period April, 1919, to March, 1920, was of the most favorable the Island has had for many years, reaching a total of fifty-seven inches, with a minimum of 1½ inches in August and a maximum of 13¼ in November. Table VI gives the data for these experiments (26) relating to *BH 10(12)* compared with *White Transparent*.

TABLE VI

Farrell's Experiment Plats, Montserrat, British West Indies

Age	Variety	Tons per acre	Data on juice					
			Extr	Gals per acre	Sucrose per gallon	Purity	Lbs sucrose per acre
Plant ..	White Transparent	21.8	60.56	2750	1.849	92.1	5090
	B H 10(12)	34.2	61.25	4350	1.997	92.6	8690
Ratoons	White Transparent	9.3		..			
	B H 10(12)	18.1					

Here, as in St. Kitts, the *BH 10(12)* ranks first of all varieties tried as both plant and ratoons in tons of cane and sugar produced per acre and in quality of juice. Tables I to VI show us that without exception in the British West Indies it has been far superior to their erstwhile standard variety, *White Transparent* (our *Cristalina*).

SC 12(4) IN ITS SUPPOSED COUNTRY OF ORIGIN

Earle (8) describes this variety as follows:

> "Erect, good vigor, fair stooler. Stalks long, medium diameter, green with reddish flush, light bloom. Internodes medium to long, cylindrical or a little compressed, staggered, furrow slight or none. Nodes somewhat constricted, slightly oblique; growth ring broad but rather poorly defined, even or somewhat elevated,

yellowish; root band strongly oblique, 5 to 10 mm., concolorous or paler; rudimentary roots crowded, in about 4 rows; leaf scar glabrous, broad and prominent in front, appressed behind; glaucous band constricted, poorly defined. Buds large, lanceolate, about 12 × 16 mm., exceeding the growth ring by one-third to one-half, margin broad, uniform, germination apical, heavy basal placs, abundant marginal vestiture ending in a conspicuous apical tuft. Leaf sheaths with dense vestiture along the back, the sides glabrate, greenish or slightly tinted, somewhat glaucous, the base slightly stained purple within; throat lannate and with an abundant vestiture of hairs; collar medium width, reaching the midrib, glaucous, the margins slightly lannate; ligule about 4 mm., minutely fimbriate; ligular processes none.[4] Leaf blades erect, usually even to the tips, flat, 7 cm. or more wide, dull green, minutely and sparsely serrulate, the bases even, not ciliate.''

Earle's description of the color of the leaf as dull green is rather more appropriate than Dr Longfield Smith's (24) statement that ''The leaves are darker than those of either Ribbon or Crystallina.'' It is true that during the characteristic dry periods of the Virgin Islands the *SC 12(4)* seems to maintain a much more vigorous growth than the *Rayada* or *Cristalina*, the leaves of the latter taking on the light appearance due to lack of water much more quickly than the *SC 12(4)*. Nevertheless, under normal conditions of growth, the *SC 12(4)* may be said to show characteristically lighter color than healthy *Cristalina*, the color of the leaves being somewhat comparable to that of *D 133 (Ceniza de Fajardo)* and decidedly darker than the normal color of *B–67* or *Ba 6032*.

It will doubtless be a surprise to many planters interested in this remarkable cane variety to learn that it is in no sense a St. Croix seedling, having been, like *BH 10(12)*, produced in Barbados by Mr. Jno. R. Bovell and from the same parent cane *B 6835*. An interesting parallel is the case of the two well-known varieties *D–74* and *D–95* which have done so much for the sugar industries of Louisiana and Mauritius These are not really Demerara varieties at all, having figured amongst the first seedling canes produced by Harrison and Bovell in Barbados when these two well-known cane breeders workt cooperatively in Barbados, and happening to be amongst a number of unnamed seedlings which Sir John Harrison carried with him to Demerara when he was transferred to that colony shortly after the production of these first seedlings.

When Mr. Bovell in 1912 paid a visit to the Experiment Station in St. Croix, then under the administration of the Danish authorities, he carried with him and presented to the Director of the Station several seedlings recently produced by himself in Barbados, this particular variety being a seedling of *B 6835*. Amongst these seedlings figured the one that, after long trial by Dr. Longfield Smith, then Director of the St. Croix Station, came to be known as St. Croix's most valuable cane—the *SC 12(4)*. Hence it would seem that, aside from the famous *Hawaii 109*, most of the seedlings which have gained great reputations for themselves and contributed very materially to the advancement of the sugar industries of countries widely scattered over the face of the globe have really originated in that little speck in the West Indies—Barbados.

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[4] The writer finds an occasional inconspicuous ligular process in this variety

FIG. 2.—B-6835, the Parent Cane of both BH 10(12) and SC 12(4)

In 1921 Dr Longfield Smith, in his excellent article on "Sugar Cane in St Croix" (23) wrote as follows

"*Seedling SC 12/4.*—This cane has given an average increase per acre over the Ribbon cane of 3.4 tons of cane and 1,197 pounds of sucrose extracted by the small mill. The tonnage represents an increase of approximately 12 per cent, and the sucrose an increase of approximately 20 per cent. . . . . Over 100 acres of it are now under cultivation in St. Croix. The Mount Pleasant plantation reported an increase of 30 per cent in tons of cane per acre for first ratoons. Definite results from other plantations were not obtained, but it is known that this cane has shown its superiority everywhere, and that the exceptional richness and purity of the juice are important points in its favor.

"When subjected to severe drought, the mature cane of this variety has been observed to dry up more rapidly than the Ribbon cane. For this reason it should be cut earlier in the season than Ribbon cane, when there is dry weather. This year some of the plantations delayed cutting cane *SC. 12(4)* in order that the top pieces might be used for planting at the time of the spring rains. These rains did not occur, and consequently the canes became overripe . "

Table VII gives the data from plat tests at the St Croix Experiment Station in comparison with their *Ribbon* (our *Rayada*) cane

TABLE VII

Comparison of Yields Obtained from SC 12(4) and Ribbon Canes, St. Croix Agricultural Experiment Station

Plant No	Santa Cruz (12) 4		Ribbon	
	Tons cane per acre	Lbs sucrose per acre	Tons cane per acre	Lbs. sucrose per acre
1	[illegible]4.0	887	27.3	5797
2	[illegible]8.4	8790	[illegible]2.0	6521
3	29.4	6[illegible]2[illegible]	31.2	6360
4 ..	20.7	[illegible]	18.3	3524
5	25.0	[illegible]107	[illegible]2.0	6659
Average	31.5	[illegible]	[illegible]8.1	[illegible]772

IN SANTO DOMINGO AND CUBA

In very recent years both *BH 10(12)* and *SC 12(4)* have been introduced into *Santo Domingo* and *Cuba*, as well as Jamaica, and Menéndez (14) states that "their behavior in those countries is corroborating our experience in Porto Rico" He goes on to say

> "Whether their peculiar characteristics will make them adaptable to those countries remains as yet to be seen; but from personal experience of the writer it seems that their trial on a large scale is worth being taken into consideration by the cane growers of the sister islands. It is the personal opinion of the writer that because of its stronger stooling and ratooning power and general hardiness as a growing plant, the Barbados Hybrid has a chance at supplanting Cristalina for many sections of Cuba, Santo Domingo and Jamaica."

Chardón (5), on a visit to Ingenio San Luis in Santo Domingo, found that *BH 10(12)* and *SC 12(4)* have the same preponderance there as in Porto Rico and Cuba, stating that at the time of his visit—August, 1924—the development of these canes was truly admirable, and gave promise of magnificent results in the *vega* lands.

Rivera (16), in one of the very few available articles on sugar cane varietal studies in Cuba, gives an account of his visit to a large experimental planting of 52 selected varieties, secured from the Insular Experiment Station and several *Centrales* of Porto Rico, in the "Finca El Palomar" of Aponte & Co in the Province of Havana. The soil of this plantation is of the loose red clay characteristic of the level lands of this district At the time of his visit the plantings were seven months old and well developed He found *BH 10(12)* and *SC 12(4)* far ahead of all other varieties, it being difficult to decide which of these two was superior "The vegetation of both is superb, the Santa Cruz has the most elegant appearance on account of its robustness, but the Barbados Hybrid has by far the larger number of stalks per row These two varieties appear particularly promising and there is no doubt whatsoever that they will be extensively propagated in Cuba "

FIG 3.—Sta. Cruz 12(4) in Cuba, 8 months old
Photo by Mr P Richardson Kuntz

In a letter recently received from Mr Jas L Rogers Jr, secretary of the Cuba Sugar Club, he amply confirms Mr Rivera's observations on these varieties at "El Palomar," calling attention, however, to the necessity of further observations under distinct conditions to those of this planting As emphasizing just such a necessity it might be mentioned that Mr F S Earle, of the Tropical

Plant Research Foundation, wrote the author on 28th January last, as follows:

> "In Chaparra, on their black-coco subsoil lands, BH 10(12) is not quite at home."

The Guantánamo Sugar Company is to be credited with having introduced *SC 12(4)* from Porto Rico into Cuba since December, 1922, and has multiplied and distributed it so rapidly that there are at present many acres of it in "The Pearl of the Antilles." This seed came from Mercedita de Ponce and is probably from the original introduction of this variety made direct from St Croix by the engineer of that central, Mr Edward K Junghans The following results were obtained from the harvesting of one of their experimental fields on 2nd February of this year, the field representing a trial of *SC 12(4)* in comparison with the standard cane of Cuba, *Cristalina* (2) The cane was eighteen months old when harvested.

FIG. 5.—SC 12/4 8 months after planting in Central Palma, Cuba

TABLE VIII

Comparative Yields from SC 12(4) and BH 10(12) in Guantánamo, Cuba

Variety	Tons cane per acre	Brix	Purity
S C 12 (4)	60	17.90	82.45
Cristalina	37	17 43	82 18

Shortly after this cane was harvested, Calvino, after a visit to these plantations, writes (2):

> “But the best fields of the SC 12(4) at the time of this writing have not yet been cut, and by their general appearance we can foretell that this will yield more and give canes richer in sugar.”

In regard to the resistance of this variety to wind, Calvino goes on to say:

> “Early in March, 1925, while I was in Guantánamo, there was a heavy rainfall, the rain gauge registering over two inches. These showers came in company with a strong wind which laid flat the Purple Striped and the Cristalina canes, while the SC 12(4) . . . remained standing, as Mr. David Herrero informed us.”

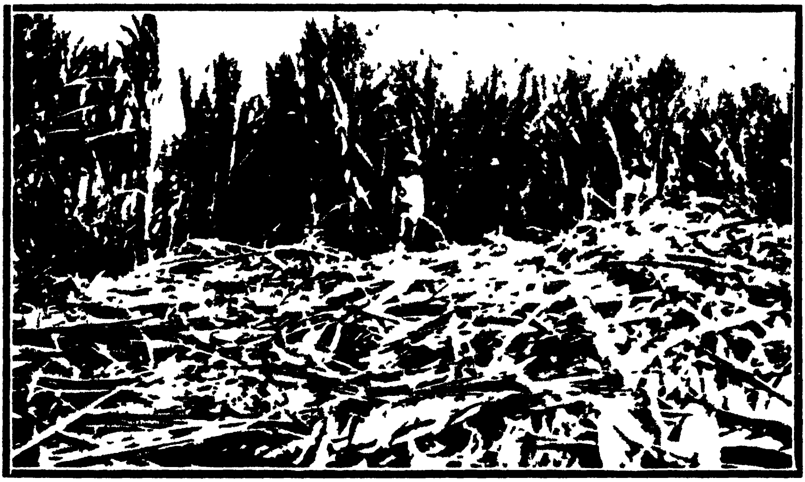

FIG. 4.—SC 12/4. This cane is 9 months old and yielded about 40 tons per acre at Central Palma, Cuba

Dr. Calvino, in the same article quoted above, gives a rather remarkable explanation of why the *SC 12(4)* is at present an erect cane, whereas Dr. Longfield Smith described it originally as inclined, as follows:

> “When Dr. Smith distributed these seedlings by pieces, he selected the superior parts of them, that is, the soundest, most vigorous and best canes of each one of them. *Thus the SC 12(4) was improved and has kept its superiority ever since*[5]”

It is hardly likely that, when Dr. Smith was propagating this seed, altho, like every plant breeder, he would select his best plants for seed, he would have been able to distribute seed only from the erect canes of a variety which he describes as "inclined," nor is there any indication in Dr Smith's reports that such an attempt was made, hence we can hardly attribute much importance to the conclusions here drawn by Dr Calvino in regard to vegetative selection inducing erect canes, even tho the selection be not made with that character in view

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[5] The italics are the writer's

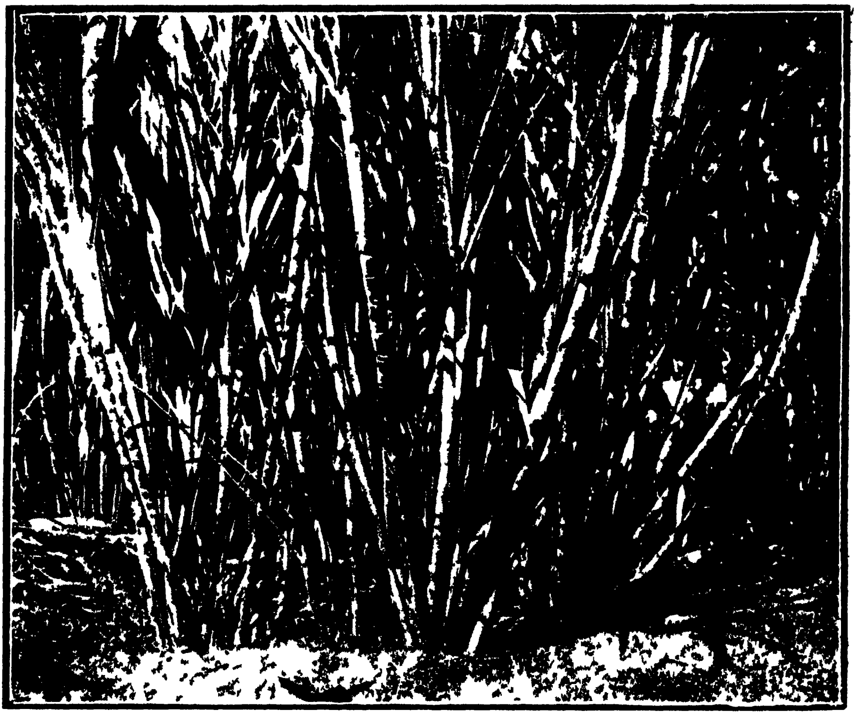

FIG 6—Typical stools of BH 10(12)

THE BH 10(12) AND SC 12(4) IN PORTO RICO

Earle (8) states that the *BH 10(12)* was originally imported into Porto Rico by Guánica Centrale in the fall of 1919, part of this seed being sent to the Insular Station, while *SC 12(4)* was imported by the Federal Experiment Station at Mayaguez, some of this seed being planted at the Station in the spring of 1919 In 1921 he stated

"This famous Barbados hybrid is making a very favorable showing It seems to be adapted to a wide range of conditions but is doing especially well on the red shale hills. It is a good germinator and ripens sufficiently early to be used either for fall or spring planting. So far it is ratooning very strong. It has every promise of being an unusually good general-purpose cane. Its resistance to root disease is evidently good. . . ''

Of *SC 12(4)* Earle (8) wrote at the same time:

''Seems very promising. It is said to resist drouth unusually well and it matures early, making it available for spring planting. . . At Mayaguez it is resisting Mosaic decidedly better than most kinds. Its sucrose quality seems very good ''

**FIG. 7.—A fine field of gran cultura of SC 12/4 at Central Aguirre, August 1925
Photo by Harold Box**

In his annual report for 1922–23, Director Menéndez of the Insular Experiment Station (12) states that ''BH 10(12) and Saint Croix 12(4) continue at the head of the list of the most promising varieties, both canes giving heavy tonnage and high sugar yields harvested as 'primavera'. Both canes have resisted drought well.'' Matz (11) in 1922 at the Insular Station demonstrated high resistance for gumming disease *(Bacterium vascularum)* for the *BH 10(12)* and by the same time both varieties had proven to be highly

FIG. 8.—SC 12 4 and Cristalina in the same field and planted at same time at Esperanza Estate, Aguirre. SC 12 4 to left of man, Cristalina to right. August, 1925

resistant to Mosaic Disease. Menéndez concluded that "all factors taken into consideration, the Barbados hybrid should be considered as the most valuable cane for most types of soil of the Island," and the following year reported (14) that "BH 10(12) continues to top the list of our most promising varieties. As the cane gives considerable tonnage in plant cane and is a good stooler and ratooner, in addition to its high sucrose content and early maturity, it is safe to predict that BH 10(12) will long be a favorite with the farmers." He reported *Santa Cruz 12(4)* as a close second to the popular Barbados seedling and that "it is being preferred to that in some districts of the Caguas valley, where it certainly grows wonderfully well." As showing the popularity today of the *BH 10(12)* all over the Island, it might be of interest to mention that for the season of 1924-25 over 20 per cent of the seed distributed from the Insular Experiment Station in response to solicitudes from planters was of that variety.

FIG. 9.—A field of BH 10(12) gran cultura on Florida estate of Central Aguirre. August, 1925. Photo by Harold Box

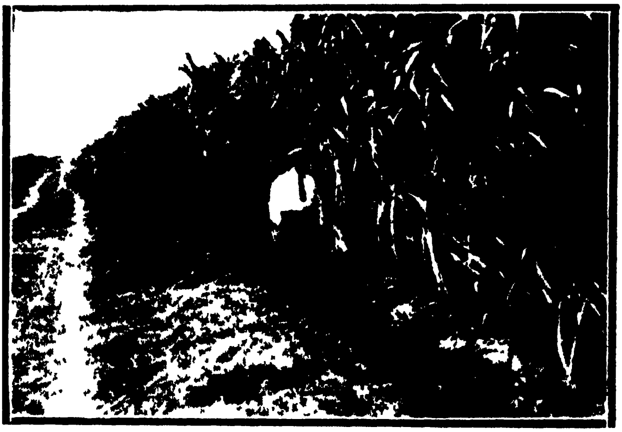

FIG. 10.—Another gran cultura field of BH 10(12) at Aguirre. August, 1925

At the end of 1921 Prof. F. S. Earle planted out a large variety plat at Central Aguirre, in which *BH 10(12)* showed up far superior on every count to every one of the great number of varieties tried. Analyses of each variety were made in January, February, March and April, 1923, the *BH 10(12)* showing up in each case first of the lot in Brix, Sucrose and Purity. Below are given the comparative analyses of the *BH 10(12)* and *Cristalina*, made the third weeks of February and March, 1923, when the cane was 14½ and 15½ months old respectively.

Month	B H 10 (12)			Cristalina		
	Brix	Sucrose	Purity	Brix	Sucrose	Purity
February	23.50	21.63	92.00	21.75	19.06	87.60
March	21.00	22.04	91.80	21.80	19.28	90.40

Of the *BH 10(12)* showing in these experiments, Mr. Earle said:

> "A remarkable record. Is best variety we have from all points of view. Splendid germinator, quick grower, very heavy tonnage, matures early and keeps remarkably in the field after full maturity. Has averaged 2 to 3 points better sucrose and purity than Cristalina and will give decidedly more tonnage on a great variety of soils. Stands drought well."

While, naturally, giving far better industrial yields if cut fairly late in the season, both *BH 10(12)* and *SC 12(4)* give really remarkable sugar contents as early as January and February, generally showing up as superior to *Cristalina*, one of the best canes for early cutting In January, 1924, the writer remarked in Central Aguirre and other south coast centrals that both *BH 10(12)* and *SC 12(4)* were showing purities in the factory of above 90—several points ahead of the *Cristalina* being generally ground at that time.

Mr. C. L. Carpenter, vice-president and general manager of Central Aguirre has kindly furnished us with the following comparative yields and analyses of two fields of *Gran Cultura*, one of *SC 12(4)* and the other of *Cristalina*, the two fields being side by side. These fields were located in Hacienda Esperanza and were planted and cut at the same time, hence the figures for the two varieties are rigorously comparative.

SANTA CRUZ 12(4) AND CRISTALINA CANES

Gran Cultura—17 Months

Variety	Acres	Tons cane per acre	Brix	Sucrose	Purity	Tons sugar per acre
S C. 12 (4)	6.15	77.56	18.42	16.30	88.5	9.49
Cristalina	7.57	59.80	19.92	17.83	89.5	7.95

As *Cristalina* is at its best on the south coast, this may be considered as a very fair comparison. Mr. Carpenter had the following to say in regard to this experiment:

> "We think that the SC 12-4 should not have been harvested so early. It was very green when cut and was still growing, and we feel very sure that if we had let this cane grow a few weeks longer it would have given considerably better results."

Another central on the south coast has been trying out these canes since 1919, having made direct importations of them from Barbados and St. Croix, and much valuable comparative data is available at this point. In 1920 a field of *primavera* of just three acres in extent of *BH 10(12)* yielded the surprising result of 42.70 tons of cane and 6.18 tons of sugar per acre and in 1921 another *primavera* field of the same variety, covering 48 acres, yielded 47.76 tons of cane and 6.80 tons of sugar per acre. A number of comparative tests at this central for *primavera* and *gran cultura* for the past five crops are summarized in the following table. This data is very complete and has been extremely carefully kept, hence the table should give a pretty fair idea of the comparative value of the various varieties under south coast conditions.

TABLE IX

Comparative Yields on the South Coast for the Crops 1921 25 Inclusive

Variety	Acres	Age	Tons per acre Cane	Tons per acre 96 sugar	Observations
			I Crop of 1921		
B H 1[illegible]			[illegible]8	7	
Cristal			[illegible]0	6 [illegible]	
			47.24	6.7	
Cristali			18.88	6 [illegible]	
S C 12			62.33	8 [illegible]	
Cristalina			17.88	6.0	
			II Crop of 19[illegible]		
S C 12 (4)	17.00	Prim	37.52	5.18	
B H 10 (12)	75.00	Prim	[illegible]8.19	[illegible]	
B H 10 (12)	4.00	G C	[illegible]	6.31	
B-208	1.75	G C	57.10	6.06	
B H 10 (12)	4.25	G C	82.85	10.9[illegible]	Planted after cowpeas
D 109	6.50	G C	71.86	8.7	

		III Crop of 1923			
S C 12 (4)	82.00	Prim	26.33	3.57	
B H 10 (12)	283.00	Prim	21.99	3.03	
S C 12 (4)	101.00	G C	45.11	3.57	
B H 10 (12).	156.00	G C	15.46	5.82	
S. C 12 (4)	6.00	G C	60.01	7.12	Planted after cowpeas
B H 10 (12)	12.00	G C	61.70	7.65	
S. C 12 (4)	3.50	G C	50.48	6.36	
B. H 10 (12)	31.00	G C	50.25	6.06	
S C 12 (4)	11.00	G C	56.11	6.82	
B H 10 (12).	11.50	G C	52.17	6.50	
S C 12 (4)	10.00	G C	70.57	8.88	
B. H 10 (12)	8.50	G C	80.76	10.16	
		IV Crop of 1924			
S C 12 (4)	58.00	Prim	31.34	4.25	
B H 10 (12)	476.00	Prim	29.73	4.08	
S C 12 (4)	116.00	G C	34.97	3.98	
B H 10 (12).	399.00		37.90	4.78	
S C 12 (4)	2.75	G C.	80.21	8.62	
B H. 10 (12)	7.00	G C	69.54	8.45	
		V Crop of 1925			
S C 12 (4)	23.00	G C	70.11	9.02	
B H 10 (12)	21.50	G C	92.19	11.58	
S C. 12 (4)	11.25	Ratoon	38.32	5.03	
B H 10 (12)	17.75	Ratoon	30.28	4.25	

Considering the large areas of the distinct varieties cultivated and the rigidity of the comparisons, Table IX probably represents the most complete data ever obtained on the comparative values of two canes. The 1921 figures demonstrate very clearly the superiority of the *BH 10(12)* and *SC 12(4)* over the *Cristalina* and explains the increasing areas of the *BH 10(12)* and *SC 12(4)* in the later years. Even the *primavera* of the *BH 10(12)* produced more sugar per acre than the *gran cultura* of *Cristalina*—and the yields for *Cristalina* are very good indeed and representative of about the optimum to be expected under ideal south-coast conditions—and the test of *gran cultura* of the *SC 12(4)* and *Cristalina* canes on large areas shows that the former produced an average of *fifteen tons cane and 2¼ tons more sugar per acre* than the *Cristalina.*

The comparison of *BH 10(12)* and *B-208* is particularly interesting, as *B-208* is a cane of early maturity and very high sugar content—a fit competitor for *BH 10(12).* Yet, altho. the *B-208* gave over eleven tons more cane per acre in this test, the *BH 10(12)* produced more sugar. The bad ratooning qualities of the *B-208,* other conditions being anything like equal, and its inferior drought resistance to that of the *BH 10(12)* would of themselves have contributed very largely to the replacement of this variety by the *Barbados Hybrid* which has taken place in the past three or four years, very large areas of the *B–208* having at one time been cultivated on the south coast.

In the comparison of *BH 10(12)* with *D–109,* we note that the latter has given an enormous yield after cowpeas had been turned under the land on which this experiment was made, yet the *BH 10(12)* has produced over eight tons more cane and 2¼ tons of sugar more than the *D–109.* Again there is no doubt of the superiority of the *BH 10(12),* altho, were the figures for *D–109* published without comparison with those for the *BH 10(12),* we might arrive at a very different conclusion. One more argument of the necessity always of COMPARATIVE data.

As to the comparison between the *BH 10(12)* and *SC 12(4)* there is very little to chose between them, altho the results obtained represent crops covering five years from an area of around 2,000 acres and a product of almost 70,000 tons of cane and 9,000 sugar. As *primavera* and as ratoons there is a slight difference in favor of the *SC 12(4),* but this difference is always very small, whereas in *gran cultura* the three enormous yields of over 10 tons of sugar per acre are each time given by the *BH 10(12).* In 1923 there were three slight gains for the *SC 12(4)* and an equal number of gains for the *BH 10(12),* in 1924 *SC 12(4)* was ahead of *BH 10(12)* by less than a fifth of a ton of sugar twice, whereas in the third experiment *BH 10(12)* gave four-fifths of a ton more sugar than the *Santa Cruz,* while the 1925 tests showed honors about even, except for the striking yield for the *BH 10(12)* in one test of 92½ tons of cane and 11½ tons of sugar per acre—figures which, for the length of the growing season, will rival some of the famous yields obtained at Ewa, Hawaii, from their *H–109.*

On the extreme western end of the south coast we have been fortunate enough to obtain, thru the kidness of Mr. R. L. Page, Chief of Cultivation for Russell & Co., at Santa Rita, an interesting comparison of the two canes we have been studying with *D–117,* widely known on the south coast as "Caña Guánica," due to the large acreage of this heavy cane formerly cultivated by that company. In this experiment there were two plats of each variety, running about 1¼ acres each in size, and the harvest of all of them was made on 3rd January, 1925.

TABLE X

Santa Rita Experiments with D-117, BH 10(12) and SC 12(4)

Variety	Plat	Tons cane per acre	Per acre 96 sugar	Sucrose	Purity
D-117	1	67.63	4.89	9.82	72.88
B H. 10 (12).	2	66.44	6.16	11.95	78.71
S C 12 (4)	3	76.51	6.71	11.52	76.82

While *D-117* gave about the same tonnage of cane per acre as the *BH 10(12)*, the far better sugar content of the latter resulted in its yielding 1¼ ton of sugar more per acre, while *SC 12(4)*, altho giving an agricultural yield per acre ten tons in excess of that of *BH 10(12)*, shows a gain in sugar per acre of just a little over one-half ton. So here again we do not find a great deal to choose between these varieties.

While this cane was *gran cultura*, it was evidently cut far too early in the season for it to have attained anything like maturity. In regard to this point Mr. Page writes us on 10th March, 1925:

> "You will see by this purity that it was a mistake to have harvested this cane at this time. We are now obtaining from these varieties, and even younger cane than this, as high as 19 per cent sucrose with 88 per cent purity, which would have given 50 per cent more sugar per acre than that shown on above plots."

Along the west coast, due to the ravages of Mosaic Disease a few years ago and the more or less general adaptation of the *Kavangire (Uba)* and *Java POJ* canes, very little data is as yet obtainable on these two varieties, altho both are now beginning to be planted in rather extensive areas on that coast. Agricultural Agent William Montalvo wrote us from Cabo Rojo on 13th October last that the *SC 12(4)* under equal conditions of soil and treatment seems to germinate better and give better yields than either *Cristalina* or *Yellow Caledonia*.

The Arecibo district, on the north coast, was also badly scourged by Mosaic Disease and at Central Los Caños, under the progressive administration of Mr. Antonio Fraticelli, large areas of *Kavangire* and *POJ* canes have been cultivated and given very good results. Some *BH 10(12)* has been cultivated at this central in recent years and Mr. Fraticelli has kindly furnished us with the following comparisons between this cane and *Rayada* during the past two crops.

PLATE IV.—BH 10(12) at "Los Caños". Gran cultura at 10 months. There are 45 acres in this field

TABLE XIII

Arecibo River Experiment

Variety	Tons per acre
D-109	48.33
D-117	43.75
B-208	43.33
SC 12(4)	50.95
BH 10(12)	50.00

Here again the *SC 12(4)* and *BH 10(12)* head the list of varieties, with almost identical yields per acre, thus again making our choice between the two varieties difficult.

Some ten miles east of Cambalache and under very similar north-coast conditions lies Barceloneta, near which is Central Plazuela, the capable agricultural superintendent of which is Mr. E. D. Colón, formerly Director of the Insular Experiment Station. Mr. Colón has kindly furnished us the following data on *BH 10(12)* at Plazuela:

> "On account of a lack of available land at the proper planting time we have not propagated the BH 10(12) variety to the extent that would have been justified by the good qualities it has shown here both in field and factory. In January, 1924, we cut and ground a plat of around one acre in extent of this variety. It yielded at the rate of 800 *quintales* per acre on *poyal* land with only a few months of rest between plantings. I give you below the average analysis of this cane compared with other varieties close by and grown under the same conditions, cut and ground at the same time The figures given are for normal juice in the *Plazuela* factory.

Variety	Brix	Sucrose	
BH 10 (12)	17.83	15.27	85.66
Ravada	16.80	14.48	86.20
D-433 (Ceniza)	15.60	12.27	77.30

From the Vega Baja district, some eight to ten miles east of Plazuela, we have very little data on these canes, except the ocular observation of the writer that both are doing extremely well in this zone and the statement in a letter from Agricultural Sub-Inspector Elías Hernández to the effect that there is "great enthusiasm" for these varieties over his entire district.

Central Victoria, located near the town of Carolina, some seven to eight miles from Río Piedras, has been cultivating these two canes to some extent since 1921 and in this past crop *BH 10(12)* broke all records in that Central for high yields in the factory. Mr. José F. Cordero, the capable Inspector of Colonies at Victoria, has been trying out and observing these canes for the past four years, not only in the Victoria fields, but over the entire district. He states in a letter to the writer under date of 29th May, 1925:

> **"I have tried out both of these canes under distinct cultural conditions and on various classes of soil, planting in holes and *en chorro* on both *vega* and semi-high lands, always in comparison with the *D-109* and *D-433* varieties and, both as regards general development and tonnage, I can assure you that they are superior to any other variety tried."**

Mr. Cordero considers the *BH 10(12)* a slightly better germinater than the *Santa Cruz,* in which observation the author agrees entirely. It has also been the writer's observation on both the north and south coasts that the *Barbados Hybrid* seems to resist protracted drought longer than the *SC 12(4),* altho the latter is drought resistant, once it has gotten a good start, in very high degree.

Mr. R. Myohl, the very capable manager at Central Victoria, has been kind enough to furnish us with the following comparative data of *SC 12(4)* and *Rayada* obtained from grindings at that Central during the past crop:

TABLE XIV

Comparative Factory Yields of SC 12(4) and Rayada at Central Victoria

Variety	Kind of cane	Age (Months)	Class of soil	Month cut	Factory yield
S. C. 12(4)	Primav.	11	High and dry	End Feb.	11.97
Rayada	Primav.	10	High and dry	Early Apr	13.16
S. C. 12 (4)	Primav.	12	High and dry	End Feb.	13.91
Rayada	Primav.	13	High and dry	End Feb	13.16
S. C. 12 (4)	Gr. Cul.	15-16	Low and wet	January	11.21
Rayada	Gr. Cul.	15-16	Low and wet	January	10.91
S. C. 12 (4)	Gr. Cul.	15-16	Low and wet	January	10.82
Rayada	Gr. Cul.	15-16	Low and wet	January	10.66

It will be seen from this table that the *SC 12(4)* has in all cases given slightly better factory yields than the very high sucrose content *Rayada,* all yields being a bit low for these canes, as the cane was cropped quite early in the season. In the first *primavera* comparison the *SC 12(4)* has the advantage of one more month's growth than the *Rayada,* but this should be somewhat compensated by the later cutting of the *Rayada.* However, in the second *primavera* comparison, it will be noted that 12-month-old *Santa Cruz* has given a slightly better recovery factor than 13-month-old *Rayada* cut and ground at the same time.

In regard to the *BH 10(12),* Mr. Myohl advised that they had no comparative figures as yet, but concluded:

> **"We, however, did grind some *Primavera* canes of this variety belonging to one of our *colonos* in the Trujillo Alto district. Those canes we ground in May**

when about 11 months old and their average yield in the factory was about 14.48 per cent, some analyses running as high as 15.46 and 15.30 per cent.''

These are, indeed, very promising factory yields for 11-month-old cane. The writer saw these fields of *BH 10(12)* and they certainly showed very good tonnage for the soils of the Trujillo Alto district.

From Victoria to Central Fajardo, on the northeast extremity of the Island, conditions are fairly similar, hence we may next turn our attention to the experience in this most progressive central with these two varieties. As is well known, Central Fajardo maintains its own experiment station, under the competent direction of Mr. R. A. Veve, and it is due largely to the practical investigations carried on by this station that the *D-433* practically replaced all other varieties in that section and is now in turn beginning to be replaced by varieties developed at the Fajardo Station—amongst the most promising of these being *F. C. 306, 214* and *140* in the order named. Mr. Veve wrote us in August, 1924, that their data on the *BH 10(12)* and *SC 12(4)* were quite limited, as they had started work with them only the previous year, but added that "We are propagating very heavily the BH 10(12), which seems to be the one best adapted to our conditions" From the 1923–24 Annual Report of this Station we obtain the following information:

Variety	Age	Acres	Tons per acre		Brix	Purity	Factory Yield
			Cane	Sugar			
SC 12 (4)	Gran Cult	3.57	37.63	4.10	18.1	81.4	10.9
BH 10 (12)	Primavera	1.63	36.79	3.78	16.8	83.9	10.3

while from the monthly report for May, 1925, we compile the following interesting comparisons.

BH 10 (12)	Primavera	1.75	41.33	5.25	19.6	88.2	12.7
D-433	Primavera	6.22	46.69	4.86	18.1	81.9	10.4
BH 10 (12)	1st Ratoon	89	28.19	4.28	21.8	91.7	15.0
R S Caled	1st Ratoon	1.06	39.06	4.10	18.6	86.9	10.5

The fact that *gran cultura* of the *SC 12(4)* gave very little more cane and sugar per acre than the *primavera* of the *BH 10(12)* would seem to bear out Mr. Veve's opinion that the *Barbados Hybrid* seems the better adapted of the two to their conditions, but more extensive trials of the two canes will be necessary before this point can be settled As regards the comparison with the *D-433*, the results are all in favor of the *BH 10(12)*, while as ratoons the Barbados cane seems far superior in general to the *Red Striped Caledonia* developed by Fajardo. This cane is a sport of Yellow Caledonia, known in Hawaii as "Big Ribbon."

Central Ejemplo, located near Humacao, about the center of the east coast, has, thru the courtesy of Agricultural Sub-Inspector E. Molinary Salés, furnished us with the analysis of one lot of *SC 12(4)* cut during the first part of January of this year. This field gave 57 tons of cane per acre, and the juice showed 17.8 Brix, 15.46 Sucrose and 86.85 Purity—very striking figures indeed for that early cutting.

Central Mercedita de Yabucoa, located on the southeastern extreme of the Island, of whose agronomical laboratory Mr. F. Colón Moret, formerly of the Insular Experiment Station, is chief, has only this past year started extensive plantings of these two canes, altho one seven-tenths acre nursery of *BH 10(12)* at the age of ten months yielded the very satisfactory figure of 47.37 tons of seed cane per acre. An interesting feature in regard to *BH 10(12)* at this central is that this company recently imported from Barbados a number of barrels of seed of the strain of this cane which Mr. Jno. R. Bovell, Director of Agriculture in Barbados, thought might be immune to Mosaic Disease This cane has been planted at Mercedita de Yabucoa, Pasto Viejo, near Humacao, and at Coloso, on the west coast, and we understand that in no case has it proven immune to *Matizado.*

We have now covered the entire coastal plain of Porto Rico, there remaining one very important and valuable cane district—that represented in the hill section extending from Humacao, on the east coast, to Caguas, some fifteen miles south of Río Piedras, most of this district being located at an elevation above sea level of from 150 to 350 feet Both *SC 12(4)* and *BH 10(12)* have been considerably cultivated in this district in recent years, Central Juncos having made a direct importation of the former from St. Croix. Mr. Juan Pujadas, Chief of Cultivation at Juncos has been kind enough to furnish us with the following comparative tonnages of cane per acre from an experiment with *SC 12(4)*, *D-117* and *Rayada* planted as *Gran Cultura* in a field of apparently very even composition thruout, the canes having been recently harvested at the age of eighteen months:

D-117, 57.50 tons; *SC 12(4)*, 57.30 tons; *Rayada*, 53.30 tons.

Mr. Pujadas also advises that they have records of tonnages from *SC 12(4)* at Central Juncos of 45.48, 49.54, 56.45 and 64.12 tons per acre. He considers it rather a slow germinater, but a fast grower once its root system is established, altho not a quick closer on account of its very erect type of growth.

As *BH 10(12)* has been mostly cut for seed at Central Juncos, no comparative tonnage data are available here, but it is the author's observation that over this entire district *SC 12(4)* seems to give a more luxuriant growth and rather higher tonnage than *BH 10(12).*

We may terminate our reconnaissance of the Island by citing two sets of extremely interesting and pertinent figures taken from circulars issued by Central Santa Juana, near Caguas, under date of 13th and 19th May, 1925. Table XV gives the analyses made at that central of four carloads of *BH 10(12)* from a field which yielded 35 tons of cane per acre, the crop and analyses being made on the 6th, 7th and 8th May last:

TABLE XV

BH 10(12) at Central Santa Juana

Car No	Brix	Sucrose	Purity	Factory yield
1	23 4	22 16	94 7	16 70
2	22 0	20 97	95 3	15 90
3	22 9	21 16	93 7	16 16
4	22 6	21 32	94 3	15 13

On the basis of liquidation to the *colono* at 65 per cent of the sugar recovery, this cane paid the grower at the remarkable average rate of 10.55 per cent, or a higher figure than that of the *total yield* of the majority of our centrals, his proceeds, calculating the value of sugar at but 4 cents per pound, amounting to almost $300 per acre.

Our last table gives in detail the results from the grinding in Central Santa Juana the latter part of this crop of 17 carloads of *SC 12(4)* cane from a field of a little over 6 acres belonging to Mr. José Ramírez, of Caguas. This cane was *primavera* planted in April–May of last year, so that it was just one year old when harvested. It yielded at the rate of 44 tons of cane per acre.

TABLE XVI

SC 12(4) at Central Santa Juana

Date	Net weight of car lbs	Crusher juice		Factory yield		Sugar to Colono lbs.
		Sucrose	Purity	Total	Colono	
IV-29	30,000	18.01	91.8	13.34	8.67	2601
IV 29 . .	22,400	18.18	91.8	13.44	8.74	1958
IV 30 .. .	27,940	19.68	93.7	14.72	9.57	2674
IV-30	34,520	19.64	93.0	14.68	9.54	3293
V 1.......	28,640	20.19	93.1	15.20	9.88	2830
V-1	29,020	19.49	92.8	14.59	9.48	2751
V 2	31,100	18.11	91.4	13.40	8.71	2709
V 2	27,180	19.95	95.2	15.04	9.78	2661
V 4	30,120	19.97	94.1	15.05	9.78	2946
V 5.	31,040	20.16	95.0	15.23	9.90	3078
V 5	34,980	20.13	91.5	15.37	9.99	3495
V 5	32,380	20.12	91.4	15.18	9.87	3196
V 7	36,700	19.78	94.1	14.86	9.66	3545
V 7	29,400	19.36	93.9	14.57	9.47	2775
V 7	35,200	20.07	93.3	15.10	9.82	3457
V 7	31,880	19.66	92.7	14.65	9.52	3035
V 9...... .	36,040	19.06	92.6	14.18	9.22	3323
Totals .	528,440					50322

These are indeed remarkable figures for *primavera* of *any* variety *anywhere*, showing an average return to the *colono* of 9.52 per cent, or 4-1/5 tons of sugar per acre, which, with sugar at only $4 per hundred, would be worth $336 per acre.

CONCLUSIONS

1. The Barbados *Hybrid 10(12)* and *St. Croix 12(4)*, both of which were bred by Mr. Jno. R Bovell in Barbados from *B 6835*, are undoubtedly the two most popular varieties on the Island of Porto Rico today and are rapidly replacing older standard varieties all over the Island, particularly on the south coast, where optimum conditions are found for them and where probably 50 per cent of the cane area is occupied by these two varieties.

2. In the British West Indies experiments for many years have demonstrated the superiority of the *BH 10(12)* to the standard cane usually grown in those islands, their *White Transparent*, corresponding to our *Cristalina*.

3. *SC 12(4)* has consistently given the best results of any variety employed on the Island of St. Croix.

4. These canes have of late years been taken to Cuba and Santo Domingo and are giving much promise on both islands, the St. Croix cane having probably aroused more enthusiasm than the *BH 10(12)* and there being a considerably larger area of the former in Cuba than the *Barbados Hybrid.*

5. All around the coastal plains of Porto Rico it is difficult to choose between these two varieties, which have shown uniformly superior results to all other canes with which they have been in competition, including the *Cristalina, Rayada, D-109* and *B-208,* while in the hills between Humacao and Caguas the preponderance of evidence obtainable would indicate that the *SC 12(4)* is slightly more at home under the conditions of this section than the ***BH** 10(12),* altho very promising results have been obtained with the latter thru this entire district.

6. Our Porto Rican planters who have not given these two varieties careful trials under the conditions of their particular plantations would indeed do well to do so, as they give every promise of becoming the standard canes of our Island for the better lands.

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FOREWORD

All papers published in this number of the JOURNAL were read at the meeting held by the Association of Sugar Technologists of Porto Rico, at the Porto Rican Atheneum, at San Juan, P. R., on the 5th of July, 1925.

Three other papers were read at this meeting as follows:

1. The BH-10(12) and SC-12(4) Canes, by A H Rosenfeld.
2. Origin and Development of the Cane Sugar Industry in Porto Rico, by F. A. López Domínguez.
3. The Effect of the Root Rot Fungus, *Nematosporangium aphanidermatum* (Edson) Fitzpatrick, on the Germination and Growth of Sugar Cane Seedlings, by B A. Bourne.

Of these, the first was published as No 3 of Vol. IX of this JOURNAL, the second will be published greatly expanded in a coming number, and the third was withdrawn from publication by the author, who expressed the desire of doing a more exhaustive study of the subject before publishing on it.

The Association had Dr W. A Orton, Director of the Tropical Plant Research Foundation, of Washington, D. C., for its guest of honor on this occasion. Dr. Orton gave a very interesting talk upon problems in tropical agriculture and the future work of the Foundation.

F. A. LÓPEZ DOMÍNGUEZ,
Editor.

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AN EXPERIMENT ON DRAINAGE BY MEANS OF PUMPS

IN THE CANE PLOTS "MANUEL MOLINA",[1] "FABRICA PAJAS 1ª.",[2] AND "FABRICA PAJAS 2ª.",[3] OF THE GIORGETTI COMPANY, IN THE MUNICIPALITY OF BARCELONETA, YEARS 1923-1925

By E. D. COLÓN, Agronomist and Field Manager, Compañía Giorgetti, and
J. E. BERROCAL, Agricultural Chemist, Compañía Giorgetti

TOPOGRAPHY

The 43.50 acres to which this experiment refers lie at a little over one kilometer to the west of the town of Barceloneta and of the Plazuela Sugar Factory. They comprise three distinct fields which stretch from south to north in the order "Manuel Molina," "Fábrica Pajas 1ª.," and "Fábrica Pajas 2ª". The last two fields are named after the old "Pajas" mill built at the foot of the calcareous knoll which rises close by, the oldest factory known in the surroundings, the ruins of which may still be seen there. The east end of the knoll slopes and gradually merges into the lots "Manuel Molina" and "Fábrica Pajas 1ª.," for a short distance, forming the higher part of the 43.5 acres. The rest of the land is low, marshy, clearly muck-like at intervals, where the dark color of the wet soil becomes deeper. These characteristics become less pronounced in other neighboring fields toward the east, as the relatively higher levels of the valley of the Manatí river are approached, on the other hand, they are more noticeable as we travel in the opposite direction toward the muck soil and *blanquizales*[4] of the Tiburones marsh lands. So, then, these lots occupy an intermediate position representing a transition between the predominantly organic soils of the Tiburones basin and the predominantly mineral soils of the banks of the Manatí river. In the topographical chart drawn by the engineers J. D. Schuyler and J. M. Howells in the course of their studies for an irrigation project of the Plazuela holdings, these plots are traversed by the contour lines of 3, 4 and 5 feet of elevation above mean high tide. At present the land measures lower than this at various places if computed on the basis of the mean high tide. This might be explained by the fact that the tide records taken by these gentlemen were obtained during the months of March to September, thus leaving out of their observations, other months when very high tides occur. The calcareous strata of the neighboring hills affect visibly the chemical composition and the physical structure of the soil in inverse proportion to the depth at which they lie under the more recent deposits which constitute the soil These strata are also responsible for the springs locally called *cáncaras*, common to this region, which come to the surface when the underground currents flowing between the strata of the tertiary calcareous rocks are for one cause or another interrupted in their course.

---

[1] Previous estimate, 18 acres actual measurement in 1925, 17.5 acres

[2] Sixteen acres

[3] Ten acres

[4] '*Blanquizales*' is the local name for patches of the marsh lands, which present an ash like, whitish color on the surface.

CONDITION OF THE LOTS

At the time when this experiment was planned, the lots referred to were covered by a net of water-furrows, quarter-drains, lateral and main-ditches common to the "grand-bank" system used in Porto Rico under these extreme conditions of soil moisture. This situation was further aggravated by the continuous use and cleaning of the ditches, which had made them larger than they were originally intended to be The water level in this net of ditches oscillated with the rainfall and with the tide, which had full access to them, while the outflow was never enough to drain them completely. At the lowest places the water level rose to the surface of the soil when the tides coincided with heavy rains. Springs were more abundant in the fields nearer the Pajas knoll. Some of the *cáncaras* furnished mildly brackish water, often used for domestic purposes in times of drought. In their surroundings the muck-like condition of the soil was extraordinarily accentuated When dry, a fine white eflorescence appeared on its surface. The almost constant saturation of the wet, soft subsoil, riddled often by large-size and small-size crab holes was apparent by inspection of the inside perimeter of the ditches.

The newly extracted clay subsoil was bluish white. The cane plants growing on this land were of yellowish foliage; they exhibited prematurely dried leaves, adhering close to the stalk, and showed a very poor stand. The Para grass languished at intervals, in the ten acres given up to pasture, overcrowded by vegetation more resistant to excessive moisture and salts, such as lichens, algae, eneas, (*Typha angustifolia*) arrocillo, (*Paspalum paniculatum*) salvia,

(*Salvia oficinalis*) and various reeds It was impossible to mistake the fundamental cause of the low production, heavy annual replantings, and the relatively short duration of the plantings. There were also other contributing causes, almost as apparent as the fundamental cause; such as excessive distance between stools and between rows, and the salt concentration on the surface due to surface evaporation.

PREVIOUS PRODUCTION AND COSTS

The available data cover the year 1912 to 1923, when these fields were plowed and planted as *gran cultura*, as will be explained further on.

TABLE NO. I

YIELD IN HUNDREDWEIGHTS PER ACRE

	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	Average	Average Yield of the 3 lots
M Molina 18 00 acres	Fall Planting (Gran Cultura) 352	1st Stubble 279	2nd Stubble 199	. . . . . .	.	Fall Planting (Gran Cultura) 584	1st Stubble 383	2nd Stubble 225	3rd Stubble 392	4th. Stubble 270	5th Stubble 220	6th. Stubble 208	311 (8)	316
Fábrica Pajas 1 16 00 acres	2nd Stubble 298	3rd Stubble 386	4th Stubble 290	5th Stubble 305	6th Stubble 366 (4)	.	Fall Planting (Gran Cultura) 500	1st Stubble 225	2nd. Stubble 391	3rd Stubble 270	4th. Stubble 200	5th. Stubble 298	321	
Fábrica Pajas 2, 10 00 acres	. .	.	Spring Planting (Primavera) 492	1st Stubble 222	2nd Stubble (4)	3rd Stubble 153	4th Stubble 200	. . .	Fall Planting (Gran Cultura) 400 (5)	1st Stubble 264 (6)	2nd. Stubble (7)	. . . . .	280	

(1) The crops of both lots were counted together in this year 1916
(2) Five acres were cut for seed no record of their yield is available
(3) Ten acres were cut for seed no record of their yield is available
(4) The lot was surveyed in 1925 and the area was found to be 17 5 acres This would bring up the yield to 320 *quintales*

We have available only the cultivation costs for some of these years from 1912 to 1923. The costs of planting and cultivation for the *gran cultura* in "Manuel Molina" in 1917 reached, with the wages prevalent at that time, $4.69 per ton of cane; those for the *gran cultura* in "Fábrica Pajas 1ª." were, in 1918, $5.41 per ton; and those of *gran cultura* in "Fábrica Pajas 2ª" in 1920 (taking the mean cost of plant cane for that year, which tended to be lower, as there were no specific data for this field), $5.56.

Evidently this land required closer attention.

PREVIOUS STUDIES

Fortunately we had in our local literature the valuable work by Dr. Zerban, "The Marsh Lands of the North Coast of Porto Rico,' Bulletin No. 4 of the Experiment Station of the Sugar Producers' Association of Porto Rico,[1] published in April 1913. The land to which this paper refers, is part of the "Hacienda Pajas" mentioned in his report, the only difference being that he operated a little farther to the northwest, in "Tablón 3," which at present is included in the field "Terrón," of the Giorgetti Company.

Dr. Zerban recognized drainage as the first necessity of the lands he was investigating.[2] He noticed the saline incrustations on the surface of the soil, and determined their percentage composition in Pajas[3] as follows:

Carbonic acid	0.00
Bicarbonic acid	7.08
Chlorine	50.36
Sulphuric acid	5.17
Calcium	3.90
Magnesium	1.37
Potassium	2.51
Sodium	29.59

He made determinations of the water-soluble salts in samples of soil and subsoil of the same locality and obtained the following results:[4]

	Bicarbonates	Chlorine	Sulphates
No. 10, Soil	.097%	.164%	.042%
No. 10, Subsoil	.090%	.212%	.047%

He also determined the salt concentration in the water of the ditches near the places where he had taken his soil samples, and found:[1]

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[1] Now the Insular Experiment Station.

[2] *Loc. cit.*, p. 40.

[3] *Loc. cit.*, p. 22.

[4] *Loc. cit.*, p. 25.

Parts per Million

	Total solids	Chlorine	Sulphates	Total acid radicals
No. 10	2,353.6	1,010	107.1	3,260

and he called attention to the influence of the springs of less salty water on the diminution of the salt concentration found in the water of the ditches which drained them.

With the help of Dr. Johnston, he correlated the vigor of the cane cultivated in the salty lands with the salt content of the soil, and concluded that there was a very close relation, stating that the cane did not present a normal aspect when the clorine in the soil exceeded 0.114 per cent equivalent to 0.198 per cent total acid radicals.[2] As there was no instance in which figures between 0.643 and 0.114 per cent chlorine were obtained, he could not determine the effect of these intermediate amounts on the growth of the cane. The mean between these figures would be 0.0785 per cent, which is not very far from that of 0.09 per cent and 0.06 per cent fixed by Maxwell and Eckart in Hawaii.

He attributed the poor appearance of the cane in Plot 3 of Pajas, to the high salt content of the soil, expressing the opinion that the bad effects of the salt would be even more pronounced, but for the attenuating effect of the high nitrogen and lime contents. The results of his analyses made according to the official methods (14) were as follows: (15)

Sample	Nitrogen	Phosphoric Acid	Lime	Potash
No. 10	0.38%	0.17%	1.51%	0.42%

In 1921 two samples of soil from Pajas were analysed Mr. F. A. López Domínguez, then Chief Chemist of the Insular Experiment Station. The samples were taken in the forty-three and a half acres under discussion, and the results were as follows:

Sample	No 272	No 276
Moisture	5.47	7.95
Volatile matter	18.70	22.21
Insoluble residue	56.01	54.98
Iron and Al oxides	20.22	19.60
Nitrogen	0.537	0.633
P_2O_5	0.105	0.180
K_2O	0.821	0.612
Lime	1.276	1.687

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[1] *Loc cit.*, pp 26 and 27

[2] *Loc cit.*, p 30

In the Agricultural laboratory of the Giorgetti Company, samples of soil and subsoil from this same field were analyzed in 1922 by the analysts Mr. R. Fernández García and Mr. José E. Berrocal, using official methods (16) (Hydrochloric acid of specific gravity 1.115 as solvent), and the French method[1] in the determinations of alkaline salts The results obtained were as follows:

	Fábrica Pajas No 2 By R I G	Fabrica Pajas No 1 By J E B	Manuel Molina By R F G
Soil Samples			
Reaction	Neutral	Alkaline	Alkaline
Moisture	7.715	7.092	7.442
Volatile matter	13.470 11.900 (18)	12.80 16.23 (18)	12.640
Humus	5.27 6.77 (18)	7.44	6.549
Nitrogen	0.236	0.2255 0.237 0.216	0.417 0.353 (18)
P_2O_5	0.213	0.293	0.318
K_2O	0.267	0.311	0.233
Carbonates	0 842	1.271	1.551
Bicarbonates	0.196	0.037	0.092
Chlorides	0.060	0.002	0.042
Sulphates	0 187	Traces	0 127
Subsoil Samples			
Reaction	Alkaline	Alkaline	Alkaline
Moisture	9.265	7.850	7 462
Volatile matter	11.290	13.020 12.640 (18)	10.248
Humus	4.27 4 25 (18)	5.661	4.911
Nitrogen in humus		0.1044	
Nitrogen, total	0.064	0.135	0.230
P_2O_5	0.176	0.298	0.272
K_2O	0.267	0.311	0.233
Carbonates	1.077	1 758	1.304
Bicarbonates	0.253	0.028	0.057
Chlorides	0.081	0.002	0.055
Sulphates	0.269	Traces	0.105

These analyses were followed by determinations of the weight of the soil per cubic foot to the depth of 24 inches, obtaining:

Manuel Molina	69.00 pounds
Fábrica Pajas 1ª	58.00 pounds
Fábrica Pajas 2ª	60.20 pounds

The following calculations were made on the same samples:

Weight per Cubic Foot

	In the field on the recently drawn samples	In the laboratory, on the air dried samples	In the laboratory, on soil dried at 100° C
Fábrica Pajas 1ª	100.2 97.9 (18)	62.8 59.2 (18)	58.0 55.2 (18)
Fábrica Pajas 2ª	94.2	64.0	60.2
Manuel Molina	112.1	71.1	69.00
Averages	101.1	64.3	60.60

The samples were taken in July and August 1923 and in March and October 1924, so that the moisture retained by the soil and subsoil in the open air during these drier months would be approximately 36.8 pounds per each 101.1 pounds total weight, or 36.4 per cent.

Although obtained much later than the chemical data given above, we are giving below the results of analyses of samples from these fields made according to the Dyer method as modified by the chemists of the Hawaiian Sugar Producers' Experiment Station (20), using a 1 per cent citric acid solution.

		Manuel Molina	Fábrica Pajas 1ª	Fábrica Pajas 2ª
Soil	P_2O_5	0.0182	0.01252	0.01149
	K_2O	0.01499	0.01884	0.01875
	CaO	0.8595	1.2780	0.8570
	SiO_2	0.2258	0.1252	0.1847
Subsoil	P_2O_5	0.0131	0.00502	0.00926
	K_2O	0.0133	0.01656	0.01263
	CaO	0.7035	0.8991	1.509
	SiO_2	0.2938	0.0625 (21)	0.1424

In a neighboring field, separated from the one under discussion by only a passage way (*callejón*), strong indications of the presence of ferrous salts in the subsoil were obtained, as well as unmistakable proofs of the presence of hydrogen sulphide. A silver coin was tarnished when placed in contact with the subsoil, in a hole recently made and the odor of hydrogen sulphide was distinguishable. Also, a light precipitate of ferrous ferricyanide, or Turnbull's blue, was obtained on a filter paper. The bluish white color of the fresh subsoil has been already mentioned. The water, leaking out of the walls of the ditches, leave on the subsoil tracks of a reddish-brown color, which stand out on the black color of the ground. All these were evidences of lack of ventilation.

COMMENTS ON THE FOREGOING CHEMICAL DATA

In the interpretation of results of chemical analyses of soils made by different analysts, as in the present case, experience shows that general results rather than any particular specific figure should be considered, as variations are bound to occur, even in one and the same sample, due to differences in the methods chosen, to details of manipulation, to the laboratory equipment, and to the personality of the analyst. In the data given by Dr Zerban, sample number 10, taken from the ditches, seem to show rather high results in acid radicals as compared with the figure for total solids. The figure obtained for chlorides by Berrocal in Fábrica Pajas 1 would seem to be in error when compared with the others; and these latter show considerable variations amongst themselves. The variations introduced by the washing of the soils by rainfall, and by the salt concentrations brought about by evaporation, should, however, be borne in mind, as well as the fact that until 1920 no official methods were given for the determination of alcaline salts in soils, thus giving rise to the use of different methods by different chemists, according to the necessities and personal preferences of the analysts. The determinations made on extractions with HCl of specific gravity 1.115 by Dr. Zerban, by Mr. López Domínguez, and by Messrs. Fernández García and Berrocal differ considerably when compared figure for figure; but they agree as to the mediate fertility of those soils as shown by total nutritive ingredientes With this point cleared, it is well to compare our analytical data with the standards used in other cases to judge the fertility of a soil.

For mixed soils in which clay predominates, Hilgard considers sufficient the following amounts, provided they contain a fair amount of lime, as in the present case. Nitrogen, 0.1 per cent; phosphoric acid, 0 1 per cent; potash, 0.45—0.85 per cent. Wolltman, in Tropical Africa, considers good soils those which, having 0.4 per cent lime, contain: Nitrogen, 0.12 per cent; phosphoric acid, 0.1 per cent; potash 0.2 per cent.

The foregoing standards for mineral nutrients refer to similar soil extractions with strong acids. According to them, our soils show up to be very rich.

As regards extractions with weak acids, such as citric, let us consider the following standards:

Harrison, in Demerara, fixed the following percentages as sufficient for sugar-cane raising: Phosphoric acid, 0.007 per cent; potash, 0.008 per cent; lime, 0.006 per cent.

Dyer had already fixed in a general way, a content of 0.01 per cent of P_2O_5 or K_2O as the lowest limit, at which fertilizers should be applied.

Maxwell in Hawaii considered as good soil for cane, the low lands which contained: P_2O_5, 0.0023 per cent; K_2O, 0 019 per cent; lime, 0.067 per cent.

And McGeorge, lately in Hawaii, considers as fair soils for sugar cane those containing: P_2O_5, 0.004 per cent; K_2O, 0.03 per cent; lime, 0.314 per cent.

The tendency in these standards has been to increase rather than to decrease, from Dyer on, with the exception of the figure for phosphoric acid. According to the highest standards the soils under discussion would be deficient only in available potash, a point which will be verified in due time.

THE SITUATION

This could be now stated concretely: We had a plot which was not yielding properly, almost nothing in the 10-acre lot, and at a loss in the remaining 33½ acres

The soil was not a normal mineral soil, as was shown by the muck soil still apparent in places, similar to that of the marshes to the west, the low weight per cubic foot, its high moisture-holding capacity, the low figures for "insoluble residue" and "silicates," and its high content of volatile matter, humus, and total nitrogen.

We have already seen that the potential fertility of these soils as shown by their content of phosphoric acid, potash, and lime. soluble in hydrochloric acid of specific gravity 1 115, was remarkable. And the deficiencies shown by their 1 per cent citric acid extraction, depended on the standards adopted for the interpretation of the figures obtained. These deficiencies, in any case would be shown only by the percentages for "silicates" and "potash," if the standards of McGeorge, in Hawaii, were used as basis of comparison. The high percentages of lime gave hopes of improvement, as soon as proper ventilation of the arable layers of the soil was obtained.

On the other hand, there were present dangerous amounts of salts, the concentration of which would increase with improved ventilation, unless the source of the salts, was cut off, by preventing the tides from getting into the plot, and the bad effects of evaporation were counteracted by washing accomplished by rainfall. There was, besides, one other hope of compensation in the constant flow of almost fresh water derived from the springs above described, which might at any time be used to advantage for their amelioration.

As the ditches across the plot did not drain completely in many cases even in times of low tide and the water level came up flush with the soil surface in several places in times of high tides, it was decided to carry out a drainage experiment providing for the exclusion of the tide waters and pumping out the water from the springs, seepage, and rainfall, using the least possible number of ditches, in order to compensate for the extra expense required by the operation of the pump.

EXECUTION OF THE PLAN

As a preliminary test, four acres of the higher ground of the lot Manuel Molina were planted during dry weather, in the Spring of 1923. The old canals, too wide and deep already, were filled and new shallow ditches opened. The planting was done on banks of two rows each. The banks were made with implements on the furrow made when breaking up the old stubbles just harvested. The seed used was partly of Egyptian cane (P. O. J. 105) (4½ acres) and partly of Striped Cane (Striped Cheribon) (½ acre), and the planting was done toward the end of April The yield was about 680 quintals (34 tons) per acre, harvested in May, 1924. The pump did not affect this field until the third week of November

Encouraged by the good growth of this Spring planting, we began to prepare for *gran cultura* planting the remaining 38½ acres. In the Summer of 1923, all the old ditches were filled with dirt, ash, bagasse, and trash. Of the old ditches, only the one dividing the lot Manuel Molina in two plots (one of 5 acres, and the other of 12½ acres), was kept; so also the ditches around the perimeter of the 43½ acres, and a canal 3 to 4 feet deep in Fábrica Pajas 2ª, which, stretching from east to west along very low land, could be used to great advantage for collecting the water to be pumped.

Although after filling the ditches the land was rather soft, we were able to plow and cross-plow with bulls, using a moulboard plow Wiard No. 90; then the tooth-harrow and the disk harrow were used. Furrows five feet apart were then opened with a 16-inch double moulboard plow (*fullosa*), and on the one-row banks thus formed, furrows were made with a Wiard plow No. 62. This furrow was then cleaned with a small, adjustable double-moulboard plow of

German make, or with a celery hiller. The subsoil plow was then run along both, the planting furrow and the water furrow.

Then the ditching was done. We cut two main ditches, 4 feet wide, and from 2 to 4 feet deep, perpendicular to the collecting ditch, discharging in the latter. The ordinary quarter drains (*cruceros*) 3 × 2, were opened. Ditches were further made to drain the springs (*cáncaras*) of greatest flow.

The planting was then done, in a single continuous row. The variety planted was the Egyptian (P. O. J. 105), as it was desired to find out whether it would repeat in Plazuela the good results in tonnage and quality of juices reported from Aguadilla, although, about one-forth acre of this cane had, however, been destroyed the year before, for its bad growth, in a different type of soil. The planting was finished in October 26, 1923.

Meanwhile, the installation of the pump was begun in the beginning of October, placing it at the outflow end of the collecting ditch. The ditches within the 43½ acres were isolated from any outside ditches The pump was ready to work on the third week of November.

THE PUMP

We had available the daily precipitation for 1922, measured in the water-gage at Central Plazuela The maximum in 24 hours had been, in that year, 3.62 inches on December 1, and 5.74 inches in the 48 hours of December 1 and 2.

The yearly precipitation in Barceloneta, according to the records of Weather Bureau at San Juan, P. R., varied during the years 1915 to 1922 from 45.04 inches to 74.13 inches, with an average annual fall of 59.93 inches, the most frequent and heaviest rains falling usually during the months of October to January.

In Holland, in the region around Lake Haarlem, with an annual precipitation of 27 to 40 inches, and drainage accomplished by open ditches and pumps, it has been necessary to pump up to three-eighths inch in 24 hours (21). In western England, with an annual precipitation of 50 inches, calculations for drainage are based on three-fourths of an inch in 24 hours The records for June to October 1909 at the Willswood plantation, of the County of St. Charles in Louisiana, the precipitation and lands of which are similar to ours, and where the system of open ditches and pumps was also used for drainage, show that in two instances they had to pump 1.4 and 1.03 inches in 24 hours, after a rainfall of four inches; the ordinary pumping required is, however, of 0.7 to 0.8 inch in 24 hours. Referring to this case, Elliot considers as probably sufficient, a rate of 0.75 inch. Basing his calculations on a maximum precipitation of 24 inches, during the months of July and August (23), J. O. Wright estimated the rate of drainage for the Florida marshes, at 0.87 inch Wiley determined the moisture-absorbing capacity of these soils, and fixed it at 128.75 per cent, as an average of nine samples.

None of these calculations, could, however, be properly applied to our case, not even the highest, obtained for places with precipitation similar to ours, for the following reason:

1. The small area of our field, 43½ acres, compared with the thousands of acres for which the run-off in the cases cited had been calculated.

2 The low elevation of the land on the mean sea level, which gives rise to a high water level, thus diminishing the depth of soil for rainfall absorption.

3 The springs, which overflowing into the plot, increase by additional amount of water they contribute, the rate of drainage that could be otherwise obtained.

More similar than any that we know of have seemed to us the conditions described by Jones, Schlick and Ramser in the basin of the rivers Black and Pearl, in Mississippi (23). Their measurements of the run-off to drain gave 1.00, 1.17, and even 3.48 inches in 24 hours that is, about 60 per cent of the rainfall in 24 hours.

Accepting the run-off at 60 per cent of the precipitation, we would have for the 24 hours, a maximum amount of water to pump, in 1922, of 3.62 × 0.60 = 2.172 inches, not counting the water contributed by springs and seepage, which vary with differences in level of the water table

That we are not far from the truth in adopting 60 per cent as the proportion of the rainfall to drain, is shown by the following calculations, based on the water-holding capacity of the soil under consideration:

3.62 inches of rainfall in 24 hours over 44 acres (25)	— 36,067,034.08 pounds (1)
Average moisture contained by the soil in months of scanty rainfall, 36.4 per cent on the weight of the soil *in situ*.	
Ditto, to complete saturation, according to Crawley, 44 per cent.	
Surplus capacity for use in times of rainfall 7.6 per cent, which on 43½ acres	— 14,400,936.00 pounds (2)
Difference that must be drained in 24 hours	= 21,666,098.08 pounds (3)
Ratio (3) to (1)	= 60%

To drain this amount of water in 24 hours, we would have to pump at the rate of 1,805 gallons per minute.

Bearing in mind the unknown amount of water that might be supplied by the spring and seepage, it was decided to install a pump of greater capacity, (2,100–5,000 gallons per minute) operated by an oil motor, type Y, Semi-Diesel, of 15 H. P. According to the manufacturers, such a pump should be capable, under a head not to exceed 10 feet, of draining 4 inches of rainfall from 61 acres in 36 hours. As a matter of fact, there have been instances when we have had to pump consecutively during one day and night and the following day, in order to remove the water fallen. In times of drouth and no trouble in the motor we have pumped from one-half to 1 hour daily, to remove the water from springs and seepage

To test roughly the efficiency of the installation the following calculations were made, based on data obtained on May 29th, when 4.14 inches of rain fell in the course of a few hours, filling all the ditches, and flooding the lower parts of the plot.

The pump operated normally, and the water was removed in 32½ hours (1,950 minutes).

$$\frac{4.14 \text{ inches} \times 43.5 \text{ acres} \times 1{,}000{,}000}{12 \times 3.0689} = 4{,}890{,}188 \text{ gallons}$$

$$\frac{4{,}890{,}188}{1950} = 2{,}507 \text{ gallons per minute.}$$

60 % of 2,507 = 1,504.2 gallons

The efficiency of the plant then resulted too low, estimating runoff at 60% of the rainfall-probably too low for this particular case.

THE PLANTATION

After replanting and fertilizing, the cane grew without interruption and exhuberantly, an unfamiliar occurrence in these fields, the planting of a part of which at least had always been considered a waste ot time and money.

Several analyses were made of the water on samples taken at the intake of the pump, and from the outflow canal outside the lot, to compare their chlorine content. The results were unexpected. The water from the inside ditch showed a higher percentage of chlorine than that of the outside canal, as may be seen from the following figures.

Date	Number of determinations average	Parts of chlorine per million average	
		Inside	Outside
From December 20, 1923, to February 19, 1925	35	696 54	549.28

The last two weeks during which samples of water were analyzed (February 8 and 19, 1925) a mean concentration of 675 parts of chlorine per million was found, as compared with 769 parts per million found for the first two weeks (December 20 and 28, 1924). This seemed to indicate a slow washing by the fresh rainfall water.

In March, 1924, there was a severe drought. The plantation was beginning to show its effects. As a test, we decided to irrigate five acres of Fábrica Pajas 2a. with same water that was pumped from the plot. This was done, conveying the water from the discharge of the pump to the land by means of wooden conduits. The plantation improved visibly by the weekly irrigations given on the 21st and 28th of March and 4th of April. Then the rainfall made it unnecessary to continue the test.

In August, 1924, it was easy to foresee that the yield would not be less than 800 quintals per acre.

The harvesting began on January 5th, 1925, and by February 18th the 381½ acres of plant cane and the 5 acres of first ratoons had all been cut and hauled to Central Plazuela. The results were as follows:

Gran Cultura 11 months	Quintals Yielded	
	Total	Per acre
Fábrica Pajas 1	16,880 60	1,055 00
Fábrica Pajas 2	8,984 80	898 48
Manuel Molina	11,849 70	971 97
Average	37,715 10	979.61

The ratoon cane in the 5 acres flowered at 10 months. It gave 2,421 90 quintals, or at the rate of 484.38 quintals per acre.

The stubble, in general, has required very little replanting, and at the time of writing (May 1925) it is growing very well and promises to give a fair crop for 1926, with reasonable expenses for cultivation.

The results obtained have surpassed our greatest hopes. It is possible that they may be duplicated in many parts of Porto Rico.

Costs

1 Installation of pump and motor, with shed, full expense $3,546.21	
Amortization in five years, annual charge	$709.24
2. Materials for repairs and for pumping (petroleum, gasoline, oil)	461.46
3. Wages, pumping and repairs	276.57
4 Cost, planting and cultivation, 38½ acres plant cane and 5 acres first stubble	4,731.90
Total cost	$6,179.17
5. Tons of cane produced	2,006.85
6 Cost per ton of cane, counting amortization	$3.07
7 Cost per ton of cane, not counting amortization	$2.72

WHAT SUGAR-CANE VARIETY TO PLANT

By R. A. Veve, in charge of Experiment Station, Fajardo Sugar Growers.

I have taken as a subject for this paper to be read before you, "What Variety to Plant". I have taken this subject because this is an every-day question made by the cane growers, and no doubt a very important one. Offhand, it seems very easy to answer this question, especially if the person that is questioned has had any success with a specific variety of cane; he will immediately advise his friends to plant nothing but that variety that has done so well with him.

To my mind, and no doubt to the mind of most of you present, this is a very hard and delicate question to answer since it may involve great financial losses. Whenever this question is put up to me, my answer is that it is up to every cane grower to decide what variety is best adapted to his soil and special conditions prevailing in that region. Naturally I don't mean by this, that if my neighbor has exactly the same kind of soil and conditions and I have had success with a certain variety of cane that I would hesitate to recommend it to him, but I do mean that to-day in Porto Rico, and this is a very common practice, because a variety does well in one section most of the growers think that it should give similar results in the whole Island I can safely say that at present there have been great losses experienced by cane growers as well as factories due to the little or no importance given to the adaptation of varieties to the different localities. Reading the Journal of the Department of Agriculture of Porto Rico, Vol 8 No 3, for the month of July 1924, in the article "Some Java P.O.J. Seedlings in Tucumán and Porto Rico", I find a paragraph by Mr. A. H. Rosenfeld whose clear mind has sized up this question of how varieties are planted. His paragraph I quote as follows:

> "In the case of varieties of sugar cane, size and appearance, yes, even a characteristic color or mode of growth may exert more influence than their actual productivity or resistance to disease and it appears to the author that we could find no better illustration of this fact than the case of D–133, the well-known "Ceniza" cane, which has proven so valuable under the peculiar conditions of Central Fajardo, in Porto Rico. Careful experimentation and years of experience at this progressive central have demonstrated beyond the shadow of a doubt the value of this cane—normally a variety of good tonnage but indifferent sugar content—under the conditions of most of their properties, but this demonstration

under limited conditions does not justify the wide distribution of D-433 under materially distinct environment of soil and climate. No one will deny, we think, that the good size and ease of identification of this variety, as well as the notoriety it has received from its good record at Fajardo, have been more potent factors in its wide distribution than the results of carefully conducted field trials under the actual conditions of the many other sections into which it has of late years been extended.''

Just as a matter of illustration I am going to give some more details of this specific case.

The variety used in Fajardo in a plantation scale (when I say in Fajardo I mean administration cane as well as *colono's*), is the D-433; I know very well from experience as well as records obtained from other factories and experimental stations that this variety has been a great failure in most parts of the Island, but I do know that this cane has been the savior of the sugar business in our district.

In evidence of the above statement let me give you acreage and tonnage of this variety for the last five crops and the average tonnage obtained by the Fajardo Sugar Growers' plantation so that you have a clear idea of what the introduction of the variety D-433 meant for the sugar business in our region. The yearly acreage not reported as D-433 includes at least one thousand acres of BH 10-12, SC 12-4, Y.C., D-109, F C. Seedlings and other varieties exclusive of Cristalina and Ravada

Crop Year	Variety	Acreage	Tons Cane per Cda	Brix	Purity	Yield	T Sugar Per Cda
1921	All Included	9,601 7	16 75	18 25	82 90	10 70	1 79
	D 433 exclusively	453 3	26 37		82 70	10 30	2 72
1922	All included	8 615 02	20 74	18 28	81 15	10 95	2 27
	D 433 exclusively	1,517 81	33 92	18 20	82 90	10 40	3 51
1923	All included	7,773 29	19 94	18 64	81 54	11 28	2 25
	D 433 exclusively	2,495 06	26 42	18 90	81 60	11 30	2 97
1924	All included	8,045 16	26 86	17 71	82 24	10 25	2 75
	D 433 exclusively	4,095 90	32 52	17 90	82 60	10 40	3 35
1925	All included	7,435 60	31 74	17 94	82 27	10 40	3 30
	D 433 exclusively	4,215 97	35 61	18 21	82 81	10 78	3 81

NOTES:

Figures for crop 1925 only include cane harvested up to June 25, 1925.

In crops 1921, 1922 and 1923 no B H. 10-12 or S C. 12-4 were harvested, and very little for crops 1924 and 1925.

Now I will give you some data in this same variety, D-433, which have been obtained from Central Carmen, Vega Alta, and which goes to prove that a variety that behaves well in a place does not necessarily give equal results when tried elsewhere.

Kind of cane	Acreage	Tons Cane per Cda	Brix	Purity	Yield	Tons Sugar per Cda
G C	96 67	28 34	13 71	76 5	7 10	2 01
G C	9 10	13 74	15 66	77 6	8.35	3 65
Primavera	22 69	38 66	15 44	78 4	8 14	3 15

You will naturally ask the question of why these great differences. The following is my explanation:

The soils of Vega Alta where this cane was planted are of a sandy structure while the ones of Fajardo are heavy clay formations. To my best understanding this is the main reason, as it has been our experience that D-433 whenever planted in the sandy soils of Fajardo has given as poor or poorer results than the ones obtained in Vega Alta. I am only mentioning the soil factor, but there are others such as climatic conditions, cultivation, etc., which also affect the adaptability of a variety; for instance, we are propagating today a great deal of our seedling F. C. 306, which is a high-tonnage and rich sugar cane, in our plantations, yet we had to discard it from one of our estates situated in a high altitude and where the precipitation and atmospheric humidity is very great, because it is extremely susceptible to the leaf eye-spot disease

I have taken D 433 as an example, because it is the cane with which we have experimented most, but I could have used B. H. 10-12, S C. 12-4 or any of the great number of varieties we have in Porto Rico for the same purpose I have seen results obtained from S. C. 12-4 in Mercedita, Ponce, and personally examined the cane fields, and nothing better could be expected. In Humacao this variety also does excellently, yet in Fajardo our experience has been that of a very high sucrose cane but low tonnage per acre. We had a technologist from the Federal Experimental Station visiting our fields some time ago and he refused to believe that this was the same S. C. 12-4 they had in Mayagüez. I am only mentioning this to impress upon you the behavior of varieties in different localities

I also want to make clear to you that even with the good results that we have obtained with the D-433 we do not expect to keep it in our fields for a lifetime. There may be today hundreds of other varieties that will do even better than D-433 and this is the kind of investigations that every cane grower should make when possible

At present great hopes are placed in B.H.10-12 to replace D-433 as a *gran-cultura* cane (long growth), as it will give equal tonnage and higher sucrose content, but in *Primavera* planting and ratoons running between eleven and twelve months old, so far D-433 is showing some superiority.

In concluding we would recommend to all cane growers not to accept any offhand advice as to the variety he should plant unless the special variety recommended to him has been successfully and thoroughly tried out in his section.

The ideal of every cane grower is to find a high tonnage variety with an equally high sucrose content. I firmly believe that this could be attained if all the centrals of the Island that have means to do it should run experimental stations. These stations should carry out the expensive work of determining which is the variety best suited to their region and recommend it to the planters.

RELATIONSHIP OF CANE VARIETIES TO DISEASES

MELVILLE T. COOK, Plant Pathologist, Insular Experiment Station,
Río Piedras, P. R.

It is very generally recognized that some varieties of plants are much more resistant to certain diseases than others. This is very readily observed in both wild and cultivated plants. Even the most casual observer cannot fail to note that diseases do not spread uniformly through a growth of wild plants or over a field of cultivated plants. This is because some plants are more resistant than others. Susceptibility to disease may account for the complete extermination of some species and varieties of wild plants in the past. It certainly does account for the abandonment of some varieties of cultivated plants within very recent time.

The fact that some plants are more resistant to certain diseases than others has been utilized by the growers of plants for many years, in fact, this practice is so old that it is impossible to tell just when man first began to select plants that were resistant to disease. Within recent years, many diseases of plants have been brought under control by the selection of resistant strains and varieties and this method is now very generally recognized as one of the most important in our fight against the many diseases of our crops.

The sugar-cane growers of Porto Rico have long ago learned that the selection of resistant varieties is a most important method of fighting some of our enemies. The growing of the recognized varieties of twenty-five years ago, have been greatly reduced, because of their susceptibility to mosaic and new and more resistant varieties have come into use. A few years ago, the gummosis disease became a threatening factor in Porto Rico, but is now of comparatively little importance because our growers have learned that it can be eliminated by the growing of resistant varieties (See Matz, J., Gumming Disease of Sugar Cane", Journal of the Department of Agriculture, 6:5–21, July, 1922).

But our growers have also learned that resistance to dissease is only one of many variations of sugar cane. Varieties differ greatly in character of growth, amount of tonnage, fiber, sucrose, and other factors which are quite important. This is true, not only in Porto Rico, but also in other cane-growing regions of the world and is probably the most important line on which our specialists are working for the advancement of the sugar-cane industry. The result is that the development of sugar-cane varieties is receiving more attention at present than at any other time in the history of the sugar industry and new varieties are being developed in great numbers.

With these facts before us, let us inquire a little more closely into the question of varieties and their relation to the future of the cane-growing industry. It has been long recognized that all plants are subject to variation; in fact, it is often said that no two plants are exactly alike. The resemblances may be so close that it is practically impossible to detect the difference, but the differences are there; and it is this tendency to vary that has given rise to the enormous number of varieties of cultivated plants. In fact, some of the greatest advances in agriculture have been made by workers who were able to recognize and preserve valuable varieties. This has been practiced for centuries more or less blindly by men who did not understand natural laws of variation which have been demonstrated in recent years.

Varieties may arise in several ways, but the three most common are:

1. A gradual variation in which it is necessary to select the most desirable plants through a number of generations. In this manner the desired plant may eventually be secured.

2. Very pronounced and stable variations may appear within a single generation. These variations are known as "Mutants" and may be good or bad. These variations must be studied by well trained workers and tested from many angles in order to determine their relative values.

3. The careful breeding of plants by cross-pollination and production of seedling from which selections must be made by competent judges. This has become a very general practice in many of the cane-growing regions of the world and has given rise to a large number of seedlings.

The selection of desirable varieties by one who understands what is wanted may at first appear to be a simple process, but plants possess enormous numbers of characters, some desirable, some undesirable, some prominent and easily recognized, others hidden and evasive. Furthermore, this enormous number of characters are subject to an endless number of groupings. It will be readily seen that these factors give rise to a great number of complications. But this is not all; a variety may behave quite differently in different parts of the world or under different environmental conditions in contiguous territory.

The growing of new varieties has now reached proportions unthought of a quarter of a century ago and new varieties come and go with such rapidity and in such great numbers as to be almost bewildering.

It is the purpose of this paper to consider this subject of new varieties from one angle only—that of plant disease. Of course, a new variety that does not grow well, give good tonnage, good sucrose content, and possess other qualities that are desirables from the standpoint of sugar production, will be eliminated from consideration.

Many of the breeders of sugar cane are thinking more of tonnage and sucrose content than of other factors. But a cane that possesses these good qualities may also possess bad qualities such as susceptibility to some of our well-known diseases. Even a seedling from parents that are resistant to a disease may prove to be very susceptible to that same disease.

But there are two other factors which must not be overlooked. (1) An insignificant disease may find a new variety so favorable for its growth, that it will suddenly become a disease of major importance. (2) A disease of grass may find the new variety of cane to its liking and develop into a serious problem.

Let us take a few examples:

(1) Cane mosaic must have existed previous to the first report from Java in 1890. It is easy to say that it spread from Java throughout the greater part of the cane-growing world, but that it is not easily proven. However, no one who has studied the subject will fail to understand that it has a very definite relationship to other varieties. This is well know to our Porto Rican growers and the use of resistant varieties has been and probably will continue to be one of the most important methods of fighting this disease.

(2) The vascular disease or dry top rot (*Plasmodiophora vascularum*) which has been found only in Porto Rico. It is especially severe on D–109, when grown in low, rather wet land, but it also attacks several other varieties. Where did it come from? How long has if been an enemy to cane? It appears that the best method of combating this disease may be in the use of a resistant variety.

(3) The "eye spot"[1] is a very old and very widely distributed disease. It may have been in Porto Rico for centuries, but was

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[1] Sometimes called the Manatí disease.

never considered an important factor until 1923. It is now looked upon as one of our most important diseases. It has no doubt suddenly become serious because of the coming of new varieties of cane which are susceptible. In Hawaii this disease is most severe on H–109, but in Porto Rico we have a number of varieties that are more susceptible such as D–109 and FC–306. This is one of our important problems and it appears at this time that the selection of varieties and place of planting will be the two most important factors in controlling this disease.

(4) Gummosis was first found in Porto Rico in 1920, although it was reported from Australia a quarter of a century before that date. It may not be possible to determine where it originally came from or how long it had been in Porto Rico previous to its discovery, but it has been demonstrated that it can be controlled by the use of resistant varieties.

These four important diseases (mosaic, dry top rot, eye-spot, and gummosis) are well known to this audience. They have all, with the exception of the "eye spot", been discovered in Porto Rico within the past ten years, although they may have been here a much longer time. In fact, the "eye spot" may have been here almost from the beginning of the sugar industry. Their history in Porto Rico is a most excellent proof of the importance of the selection of resistant varieties in the growing of sugar cane.

The records show a dozen or more minor diseases of sugar cane in Porto Rico, any one of which may become of importance at any time provided it finds a suitable host variety. Minor diseases which suddenly become important are frequently looked upon as "new" by those who are unfamiliar with plant diseases, but if we could only learn their full history, we would find that some of them were formerly minor diseases while others may have come from related uncultivated plants.

But the selection of varieties of high tonnage, high sucrose content, and high resistance to disease must bring other factors into consideration, the most important of which are relationship to soil and climate. This is well illustrated in the case of the "eye spot" which is most severe in regions and during periods of high rainfall. Although this disease was severe in 1923, it did not attract much attention in 1924, but was very abundant in 1925. It is now looked upon by many of our growers as a disease of major importance and is one of our major problems at the Insular Experiment Station.

Therefore, it appears that the development of new varieties will very probably bring into prominence certain diseases which are of minor importance at this time and that our problems will become more and more complex. However, this must not be interpreted as an argument against the development of new varieties. The development of new varieties is the key to progress in the sugar industry in Porto Rico and in other parts of the world. But we must recognize that our troubles are not ended with the mastery of mosaic.

New and more complex problems will arise from time to time with the finding of varieties of high tonnage and high sugar content. Every advance in the development of improved varieties will introduce new problems of diseases and some of these problems may be far more complex than those that are before us.

STEAM CONSUMPTION IN AN ELECTRIFIED SUGAR MILL

By José R. Carreras, B. S., Chief Engineer, Juncos Central Co.

This paper is a brief abstract of a complete study made on the steam consumption of a sugar factory of this Island, with a quadruple effect evaporative installation, and on the expected steam consumption after the addition of a pre-evaporator which would supply also vapors to the juice heaters.

The scheme of adding a pre-evaporator to a quadruple effect forming a quintuple, and at the same time, supplying vapors at double effect to the juice heaters, is not new, as most of you may know. Noel Deerr in "Sugar" and Hausbrand in "Evaporating, Condensing, and Cooling Apparatus", treat that and similar schemes fully, and actual installations may be found in Cuba, Hawaii and other countries. So far as I know, though, this system has never been worked before in Porto Rico.

Before going into the discussion of the steam requirements, in the actual and in the system in project, a brief description of the factory apparatus and process is necessary.

Actually, the factory is almost wholly electrified. It has one 750 KW. Westinghouse Reaction type steam turbine and one 500 KW. Westinghouse Impulse type turbine. One Corliss engine of 120 HP. and one Corliss engine of 450 HP. drive most of the mill, and 100 HP. in small steam pumps are scattered in various works in the factory.

The juice is passed through three juice heaters, 1,250 square feet H. S. and heated to 212 degrees Fahr. After being clarified, it enters the quadruple effect at an average temperature of 180 degrees Fahr., and leaves as syrup of 27 degrees Beaume. Strikes of "Puras" and "first", massecuites are done in a calandria pan; "second", "third" and some "first" are done in two-coil pans.

The juice heaters and quadruple effect work with exhaust steam and the addition of live steam to mantain 6 lbs. ga. back pressure at the evaporator, or 11 lbs. ga. at the engines.

The calandria pan works with exhaust steam exclusively. The coil pans work mainly with live steam.

With the system in project, the juice heaters will work with vapors from the pre-evaporator; the pre-evaporator will work with the exhaust steam pressure same as previously; the calandria pan with exhaust exclusively, and the coil pans with live steam mainly, or if able, with exhaust steam exclusively. A new juice heater, 1,000 square feet H. S. will be installed also, for reheating the juice after clarification, and will work with vapors from the pre-evaporator.

Now, a word before submitting the results obtained. It would be foolish to claim exactness in the figures to be submitted. They represent the results from average conditions at 'the usual heavy rate of grinding and for maximum normal extraction of 83 per cent and 35 per cent dilution on cane. The calculations have been made mainly to show the relative proportions among the steam requirements of the different apparatus in the old and in the system in project. Please remember, therefore, that the tabulation of results given below must be considered as fairly approximate to the steam consumption of the apparatus.

TABULATION OF RESULTS FOR THE 750 KW. TURBINE UNIT IN SERVICE

	Live or exhaust steam consumption in lbs of steam per lb juice per hour	Live or exhaust steam consumption in lbs of steam per lb juice per hour	B T U consumption per lb. juice per hour	B T U consumption per lb juice per hour	B. T. U. consumption in per Cent of total B T U consumption	B T U consumption in per Cent of total B T U consumption
	Quadruple	Quintuple	Quadruple	Quintuple	Quadruple	Quintuple
POWER:						
Turbine 750 K. W. unit	0 2491	0 2491	25.24	25.24	4 97	6.01
Corliss Engines	0.1054	0 1054	10 19	10.19	2 01	2 48
Steam Engines	0.0616	0.0616	1 57	1 57	0 31	0 37
EVAPORATION & BOILING:						
Heating of juice......	0 1370	....	118.80	.. . .	28.88	... .
Reheating of juice	0 0464	0.0052	40.14	4 50	7 88	1.07
Evaporation...	0 2280	0 3135	192 44	270.47	37 92	64.51
Boiling in Cal Pan.....	0.0931	0.0809	80.66	70.04	15.85	16 71
Boiling in Coil Pans ..	0 0068	0.0068	6.51	6.54	1.29	1.56
Evaporation of added water in pans.........	0 0212	0.0212	20.42	20.42	4.02	4 87
LOSSES:						
Steam pipe losses........	0.0020	0.0020	2.00	2.00	0.39	0 47
Condensation losses....	0.0105	0.0087	10 05	8.40	1.98	2.00
			508.05	419.87	100.00	100.00

Comparative Heat Balance in Pounds Steam per Pound Juice per Hour, 750 KW. Turbine Unit in Service

WITHOUT PRE-EVAPORATOR SYSTEM:			
Exhaust produced by—			
Turbine	0.2491		
Corliss engines	0.1054		
Steam engines	0.0616		
		0.4161	
Exhaust required—			
First heating	0.1370		
Reheating	0.0464		
Evaporation	0.2230		
Boiling in calandria	0.0931		
			0.4995
Deficit in exhaust steam		0.0834	
		0.4995	0.4995
Deficit in exhaust steam			0.0834
Deficit in live steam equivalent			0.0746
USING PRE-EVAPORATOR SYSTEM:			
Exhaust produced by—			
Turbine	0.2491		
Corliss engines	0.1054		
Steam engines	0.0616		
		0.4161	
Exhaust required—			
First heating	0.0000		
Reheating	0.3135		
Evaporation	0.0052		
Boiling in calandria	0.0809		
			0.3996
Excess in exhaust steam			0.0165
		0.4161	0.4161
Excess in exhaust steam		0.0165	

TABULATION OF RESULTS FOR THE 500 KW. TURBINE UNIT IN SERVICE

	Live or exhaust steam consumption in lbs. of steam per lb juice per hour.	Live or exhaust steam consumption in lbs. of steam per lb juice per hour.	B T. U consumption per lb juice per hour.	B. T. U consumption per lb juice per hour	B T U consumption in per Cent of total B T. U. consumption.	B. T. U consumption in per Cent of total B. T. U. consumption
	Quadruple	Quintuple	Quadruple	Quintuple	Quadruple	Quintuple
POWER						
Turbine 500 K W.	0.1849	0 1849	18.74	18 74	3 78	1.56
Corliss Engines. ...	0.1054	0.1054	10.19	10 19	0 08	2 46
Steam Engines	0.0616	0 0616	1 57	1.57	0.81	0 87
EVAPORATION & BOILING						
Heating of juice	0 1870	....	118.80	....	28 67	. ...
Reheating of juice	0.0464	0 0052	40.14	1.50	8 01	1.08
Evaporation	0.2230	0 3135	192.41	270.17	38.87	65.58
Boiling in Cal Pan	0.0931	0.0809	80.66	70.01	16.06	16 96
Boiling in Coil Pan. ..	0 0068	0 0068	6 54	6.54	1.30	1 58
Preparation of added water in Pan	0.0212	0 0212	20 42	20.42	4.07	4 05
LOSSES						
Steam pipe Losses ...	0 0020	0.0020	2 00	2.00	0.40	0.18
Condensation Losses ..	0.0105	0 0087	10.05	8.40	2.00	2 08
			501.55	412.87	100.00	100 00

Comparative Heat Balance in Pounds Steam per Pound Juice per Hour, 500 KW. Turbine Unit in Service

WITHOUT PRE-EVAPORATOR SYSTEM:

Exhaust produced by—			
Turbine	0. 1849		
Corliss engines	0. 1054		
Steam engines	0. 0616		
		0. 3519	
Exhaust required—			
First heating	0. 1370		
Reheating	0. 0464		
Evaporation	0. 2230		
Boiling in calandria	0. 0931		
			0. 4995
Deficit in exhaust steam		0. 1476	
		0. 4995	0. 4995

Deficit in exhaust steam	0. 1476
Deficit in live steam equivalent	0. 1321

USING PRE-EVAPORATOR SYSTEM:

Exhaust produced by—			
Turbine	0.1849		
Corliss engines	0.1054		
Steam engines	0.0616		
		0.3519	
Exhaust required—			
First heating	0.0000		
Reheating	0.0052		
Evaporation	0.3135		
Boiling in calandria	0.0809		
			0.3996
Deficit in exhaust steam		0.0477	
		0.3996	0.3996
Deficit in exhaust steam			0.0477

Now, let us discuss the figures obtained for the 750 KW. turbine unit, which is our most convenient condition in the actual installation.

Without the pre-evaporator, 0.0746 pound of live steam per pound juice per hour must be added to the exhaust for the heating requirements. If we could save this live steam, the economy for a 24-hour day would amount to—

162,250 × 0.0746 × 24 ÷ 7.37 = 39,415 pounds of coal, or 17.6 metric tons per day.

Coal is considered as having 11,850 B.T U.

Efficiency of boilers as 60 per cent.

Equivalent Evaporation = 11,850 × .6 ÷ 963.61 = 7.37.

If a $10 price per metric ton of coal is considered, and if it were posible to maintain the 1,500 tons per day rate of grinding during 125 days of the season, the saving would amount to—

17.6 × 10 × 125 = $22,000 for the year.

With the installation of the pre-evaporator under the scheme explained, it is seen from the tabulations, that working with the 750 KW. turbine unit, there will not be the necessity to add any live steam to the exhaust; to the contrary, there will be an excess of exhaust steam of 0.0165 pound per pound juice per hour, which represents about 0.0165 × 100 ÷ 0.4161 = 4 per cent of the total exhaust steam produced. This excess may be employed to substitute live steam in the coil pans, and thus its loss be avoided.

For the 500 KW. unit, the difference between the deficit of exhaust steam in both cases is 0.1476 — 0.0477 = 0.0099 pound exhaust per pound juice, or 0.0894 pound equivalent live steam per pound juice per hour, in favor of the projected system. This is a saving of 21.08 metric tons coal per day, or $26,350 per 125 days grinding.

With this turbine in service, there will always be required a small amount of live steam for the normal evaporating load, and there will rarely be occasions of excess exhaust. We expect that it will prove to be the most economic scheme for the factory.

Since a pre-evaporator installed under the discussed system, completely erected with its accessories, will cost about $25,000, it is our opinion that it is a worthwhile investment to be made in any sugar factory. Its cost may be saved almost completely in just a year of grinding.

A paragraph of explanation before I close. The amount in dollars that we claim may be saved in a year of grinding, we don't mean it to be necessarily in dollars. The saving made will appear in the value of the coal economized during the year and in the value as a fuel of the bagasse pile left over as excess.

To those interested in this matter, the tabulations of results given in this paper may be helpful in some other considerations that come along with the problem, but that I do not deem proper to discuss now. Our aim has been merely now to call your attention to the distribution of the steam load in the factory and to the large saving that may be made in fuel consumption, if schemes are worked toward the diminution of the steam consumption in the evaporating and graining stations of the factory.

PORTO RICAN CANE-GRUBS AND THEIR NATURAL ENEMIES, WITH SUGGESTIONS FOR THE CONTROL OF LAMELLICORN LARVAE BY MEANS OF WASP-PARASITES (SCOLIIDAE)

PORTO RICAN CANE-GRUBS AND THEIR NATURAL ENEMIES,

WITH SUGGESTIONS FOR THE CONTROL OF LAMELLICORN LARVAE BY MEANS OF WASP-PARASITES (SCOLIIDAE) *

By HAROLD E. BOX, F. E. S. (Lond.),
Entomologist, Central Aguirre Sugar Company, Porto Rico

INTRODUCTION

The insects known as "White Grubs" are the larvae of a group of Beetles technically named *Lamellicornia* (sometimes referred to as *Scarabaeidae*), characterised by the peculiar formation of the antennae or feelers in the adult; the apical segments of the antennae are flattened out at right angles to their length to form thin leaf-like plates or lamellae. The Lamellicorn beetles occur in all parts of the world, but their numbers are more abundant and the species more varied in the Tropics than in temperate regions. Among them are included many of the worst pest of the world's food-crops of both tropical and temperate parts of the globe, but, principally owing to the fact that crop-rotation is less practised in the former, the damage due to Lamellicorn larvae is generally more severe in these parts than in cooler climates, as exemplified in those species that attack the Coconut Palm (*Cocos nucifera*, L.) and the Sugar-cane (*Saccharum officinarum*, L.).

The *Lamellicornia* are classified into about a dozen families, two of which include the species whose larvae attack sugar-cane; these are (i) the *Melolonthidae* (May-beetles, June-bugs, or Brown Hard-backs), and (ii) the *Dynastidae* (Rhinoceros Beetles, Black Hard-backs, etc.). In each of these families many thousands of species have been described and studied from all parts of the world, and include the sugar-cane grubs of Australia, Mauritius, India, Hawaii, South America and the West Indian Islands. In the countries metioned, with the exception of Mauritius and Hawaii, the cane-grubs are the larvae of indigenous species of beetles that have adapted themselves to feeding upon the sugar-cane. Mauritius suffers from the attacks of a species that was accidentally introduced from the island of Barbados some years ago, without the parasite which kept it in

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PLATE I

FIG. 1.—**Relations between the Food-plant, Pest, Parasite, and Hyperparasite** (Del. D. Wilson)

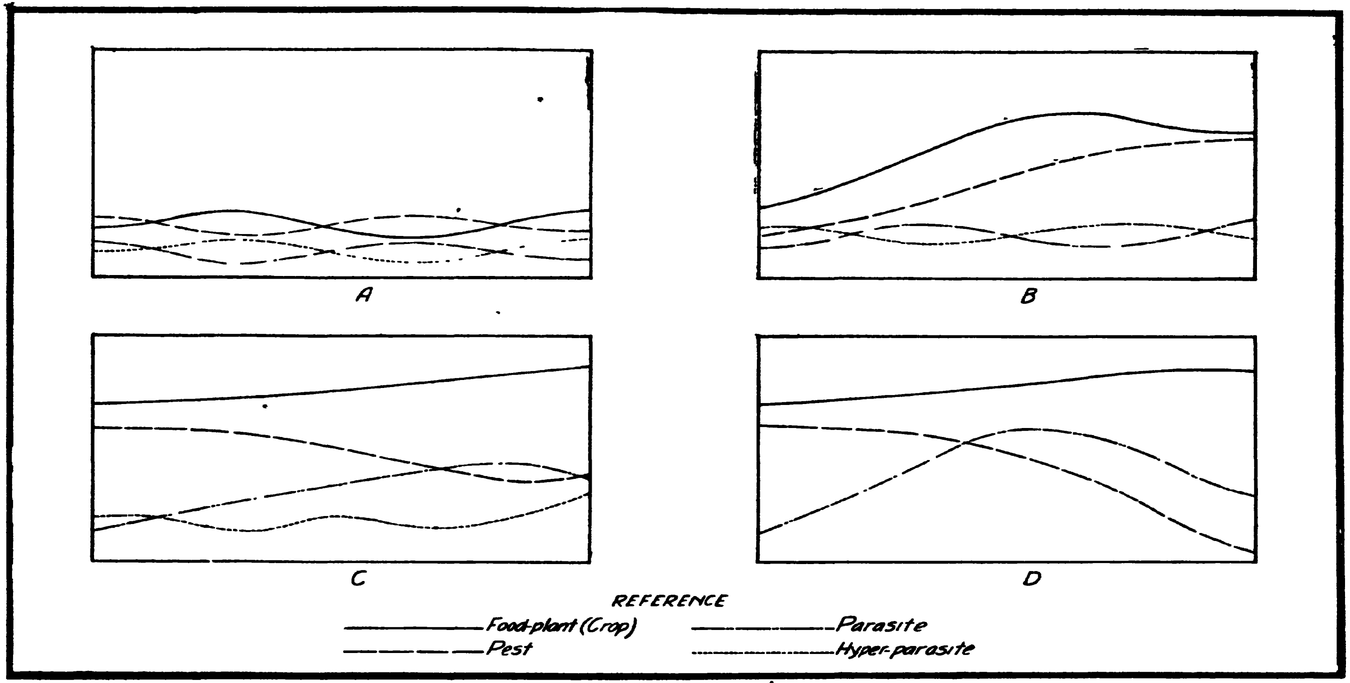

Diagram A illustrates the primeval conditions prevailing before the advent of mankind's agricultural methods, viz. a perfect "balance" between the plant, "pest", parasite, and hyperparasite, with no one of them predominating Santo Domingo today.

Diagram B illustrates the increase of the pest with that of its food plant, wwhile the parasite is still kept down by the hyperparasite. Porto Rico today.

Diagram C illustrates the effect of an artificial increase of the parasite, so that its numbers enable it to partially overcome the pest before its hyperparasite can increase in ratio Our problem

Diagram D illustrates the effect of the introduction of a parasite which has no rapid increase, eventually its numbers gradually diminish with those of the past This has occurred several times in Hawaii check in its native home, so that considerable loss was sustained before it was eventually brought under control. The canes of Hawaii were in a similar way attacked by a Lamellicorn that was inadvertently imported from Japan. In each of these instances the pest was stopped from further unlimited increase by the importation of parasites from its original habitat.

THEORETICAL CONSIDERATIONS

Prior to the planting of sugar-cane, the native species of beetles, which today are pests, took their place in the "Balance of Nature", feeding at the roots of such wild graminaceous plants as they could find, their numbers being kept from increasing by the limitation (partly by themselves) of their food-plants and the incidence of their natural enemies. Chief among the latter were sundry species of insect parasites, which were unable to exterminate the beetles as they were themselves kept in check by their "hyper"-parasites. This state of affairs is represented in Diagram A, Fig. 1, and is illustrated today in the biological status of certain insects in the eastern part of the island of Santo Domingo, paralleling pre-Columbian days in Porto Rico.

With the upsetting of the "balance" by the cutting down of virgin vegetative formations and the planting of large areas under one crop, providence was made for an almost unlimited supply of food for the pests, no account having been taken of a corresponding distribution of the plants favored by their parasites, with the result that the pests have been enabled to increase to such an extent that today their ravages are causing losses of millions of dollars to the world's sugar-industry. The parasites were prevented from increasing in proportion to the pests owing to two powerful factors: (i) the restriction of their breeding places through the gradual disappearance of their food-plants, and (ii) the existence of their hyperparasites, which, being independent of the introduced artificial conditions, retained the same relative proportions to the parasite that they held before the change took place (Diagram B). It will thus be seen that any means by which the numbers of the parasites can be raised *without a corresponding increase in the numbers of the hyperparasites,* will so enable the former to gain a temporary, or even permanent, ascendency over the latter, that a reduction in the numbers of the pest in direct ratio to such increase should follow (Diagram C).

It frequently happens that a parasite can be brought in from

PLATE II.—VIEWS IN SEIBA PROVINCE, DOMINICAN REPUBLIC

FIG. 2.—Normal condition; unfavorable to the enemies of cane pests: Miles of canes unbroken by bush or trees. (Photo. H. E. Box)

FIG. 3.—Unusual condition: favorable to the enemies of cane pests: In this instance virgin forest is (of necessity, not choice) left on a hill-slope not adaptable for growing cane. Small blocks of original growth left standing, while interfering in no way with cultivation methods, would greatly aid in cane-pest control as they would serve as sanctuaries for parasitic and predaceous enemies, particularly birds. (Photo. H. E. Box)

some other country (in which its benefits are limited through hyperparasitism), which will prove comparatively immune to hyperparasites in the country to which it is introduced, or even entirely free from their attack. Finding an unlimited amount of food-material for its progeny, in the form of the pest, and without external controlling factors, it can rapidly multiply until the decrease in the pest is the cause of its own gradual diminution in numbers. This was illustrated when *Scolia manilae* was brought in form the Philippine Islands to combat *Anomala orientalis* in Hawaii, and the effects of such introductions are represented in Diagram D.

For the successful control of insect pests by means of their natural enemies the two following points are to be observed: (i) if the pest is indigenous, raise the numbers of individuals of its indigenous parasites, and introduce others from abroad which will adapt themselves to attacking it; (ii) if the pest is an accidental introduction, search for parasites in its native home, and introduce these *without their hyperparasites.* While we may feel reasonably sure that the control of at least one of our worst cane pests—the Moth Borer (*Diatraea saccharalis,* F.)—can be obtained by means of introduced parasites, it yet remains to be seen how far we can get if similar measures are brought into play against the white grubs. The writer believes that, with a capital expenditure of less than the annual disbursements for five years in the Island upon the present, costly and ineffective collection of the adults, results could be made to follow after a few years' steady work, and it must not be lost sight of that once a suitable parasite has been found and become established, the parasite can continue breeding upon the pest without further efforts on our part, whereas with other systems of control there is a continual charge to be made every year without cessation. Large-scale operations would be more expensive, though likely to produce better and more speedy results.

INSECTS AND THEIR PROGENY

Under the present caption may be mentioned certain formulae which the writer finds convenient to adopt for computing the progeny of insects in cases where it is known that such progeny are represented by average figures or are constant for each female parent.

If *A* and *B* are the numbers of females and males, respectively, produced by one female as her progeny, and the former produce similar numbers of offspring, assuming that there is no mortality among them, or having discounted such mortality, manifestly the total female progeny, F, of N wasps will be $N\ A^n$ at the end of n generations, while the total number of males, M, will be represented by $N\ A^{n-1}\ B$; therefore the entire progeny, P, of N wasps at the end of the nth generation may be shown as follows:

$$P = F + M$$
$$\text{or } P = N(A^n + A^{n-1}B).$$

Where only a portion of the total progeny of each female reaches maturity, A and B in the above equation must be replaced by $(A - X)$ and $(B - Y)$ respectively, where X and Y are the sums of the mortalities during the early stages of each sex respectively.

The total progeny of both sexes produced by a given number, N, of females during n generations (including the nth) is calculated as follows:

$$P = N\ [(A + B) + (A^2 + AB) + (A^3 + A^2B) + (A^4 + A^3B) + \ldots\ldots (A^n + A^{n-1}B)]$$

substituting $(A—X)$ and $(B—Y)$ for A and B, respectively, where the mortality is taken into consideration.

In the case of the Scoliid wasp parasites which form the subject of the present treatise, P, in the last equation, is equal to the total number of white-grubs killed by N parasites and their progeny up to and including the nth generation..

There have been under observation at Aguirre a number of individuals of a wasp, *Dielis trifasciata*, F., parasitic on the sugar-cane grub *Lachnosterna portoricensis*, Smyth, and from data based upon rearing four successive generations of these parasities we can assume the factor A in the above equations to be 4, while B may be considered equivalent to 8. These figures are quite reasonable, for many of our egg-laying females have produced up to 15 females and 30 males as their progeny, and half of each of these numbers would still be a conservative average. Each individual wasp requires to consume one grub for its development to the adult form.

From the foregoing, we can see that at the end of one year, on a basis of six weeks per generation, the female progeny of each individual female should be

$$4^8 = 65{,}536,$$

while the total number of grubs killed (or total offspring of the original female) during the eight generations, would be,

$$(4+8)+(16+32)+(64+128)+(256+512)+(1{,}024+2{,}048)+(4{,}096+8{,}192)+(16{,}384+32{,}768)+(65{,}536+131{,}072)$$
$$=12+48+192+768+3{,}072+12{,}288+49{,}152+196{,}608$$
$$=262{,}140.$$

In nature, of course, the progression is far from even, as there are many outside factors which come into play, causing a fluctuation in the progeny of one generation from that previous to it. Also, complicated mortality factors must be taken into consideration, these being governed by climatic conditions, prevalence or non-prevalence of natural enemies, and the fact that every female is not certain to find food for her progeny. Nevertheless the formulae given above, which apply more or less equally to either pest or parasite, serve to demonstrate the rapidity with which an insect can spread if there is nothing to check it. With certain injurious insects, *e. g.*, the Aphids, the factor *P* would probably run into hundreds of millions at the end of one year if every individual developed and each female was able to oviposit at her full capacity. All epidemics of animal or vegetable organisms can be explained by means of formulæ similar to the above examples, where a geometrical progression occurs.

HABITS AND LIFE-HISTORIES OF LAMELLICORN BEETLES

There is very little variation in the general mode of life among of various species of Lamellicornia, although of course geographical, climatic, and biological factors cause greater or lesser divergences from the normal habits of the various species, and in the periods of their life-cycles. Roughly, the species in which we are interested may be divided into two groups: (i) those whose larvae feed upon the growing root-systems of living plants, and (ii) those whose larvæ feed upon injured and decaying plant tissue and other vegetable matter; in Porto Rico these groups coincide with the two families Melolonthidae and Dynastidae respectively. The following account of the life-history applies to a typical Melolonthid:

The beetles fly at night, and mating and oviposition are carried on after dark; the eggs are laid singly in the soil, sometimes near the surface, but often at a depth of a foot or even more, but invariably in close proximity to the roots of such plants as the larvae will feed upon. Each egg is enclosed in an earthen cell constructed around it by the parent female in such manner that its minimum surface comes into actual contact with the sorrounding soil, and with sufficient room to allow for an expansion which takes place in the dimensions of the egg. The egg hatches about two weeks after being laid, and from it there emerges the larva, or "white grub" as it is called, which for the first part of its existence sustains itself upon the humus present in the soil. During the larval period there are three distinct stages, or *instars*, each terminating in a complete *ecdysis*, or casting of the skin. The first instar occupies about five weeks, the second instar about eight weeks, while the third and final instar requires about six months; it is during the third instar that the grub does the greatest amount of damage. The grub at this stage is white and soft-bodied, except for the head and legs, which are composed of hardened *chitin*, and are dark reddish-yellow in color; the body is more or less covered with numerous *setae*, or short bristles, the arrangement of which, especially in the pygidial region at the posterior end of the abdomen, is characteristic of the species. The body is curved and appears to be heaviest behind, so that the grub can only with difficulty walk with its legs; it is almost helpless unless surrounded by soil. (In this respect the Porto Rican Melolonthids differ from the Dynastids, whose larvae are able to crawl at quite a good pace, even upon smooth surfaces.) When fully fed, the larva digs deeply into the ground and constructs an oval cell around itself, within the protection of which it rests awhile, later changing to the pupal stage, which occupies about three weeks; it is during the pupal stage that the organs of flight and the organs of reproduction are developed. At the end of the pupal period the insect undergoes another ecdysis, the adult beetle emerging from the membranous pupal shell. Adults frequently remain within the cell underground for several weeks before coming to the surface to carry on the propagation of the species. In the majority of cases, the life-cycle of the Melolonthids occupies nine or ten months, there being one generation annually, but many of the Dynastids, on the other hand, finish their entire development within three months while some foreign species need three years for their complete metamorphosis. A knowledge of the details of the life-cycle, and especially of the seasonal distribution, of each species is absolutely essential before its biological control can be accomplished, and fortunately, in Porto Rico we have available the results of the studies of these subjects made by Mr. Eugene G. Smyth, one of the entomologists attached to the Río Piedras experiment station in the early days of its establishment.

The habits of the adult Lamellicorns show considerable variation in different countries, but it may be stated that in general those of the Melolonthidae feed upon the foliage of certain trees, while those of the Dynastidae prefer succulent stalks of plants, *e. g.*, sugar-cane or decaying plant tissues. During the hours of daylight the adults are to be found underground, and a habit characteristic of the Porto Rican Melolonthids of the genus *Lachnosterna* is that of congregating in numbers in the soil at the base of wooden posts, trees, etc. Positive phototropism is shown by nearly all species, but generally the Dynastids are more readily attracted to artificial light than are the Melolonthids. During hours of daylight a negative phototropism is exhibited, with a pronounced tendency to positive geotropism.

THE SUGAR-CANE WHITE GRUBS OF PORTO RICO

The Lamellicorn beetles whose larvae attack sugar-cane in Porto Rico may be conveniently classified as follow:

A. MELOLONTHIDAE:
  1. *Lachnosterna* * *portoricensis*, Smyth
  2. *Lachnosterna vandinei*, Smyth
  3. *Lachnosterna guanicana*, Smyth
  4. *Phytalus*** *apicalis, Blanchard* (=P. *insularis*, Smyth)

B. DYNASTIDAE:
  5. *Strataegus titanus*, Fabricius
  6. *Ligyrus tumulosus*, Burmeister

DISCUSSION OF THE PORTO RICAN CANE-GRUBS

In the following, the dimensions and periods of the life-cycles have been taken from Mr. Smyth's publications

1. *Lachnosterna portoricensis*, Smyth

Dimensions in millimeters:

Adult	17–23
Egg	3.0 × 1.75
Larva, 1st instar	6–18
Larva, 2nd instar	18–30
Larva, 3rd instar	30–48
Pupa	25–29 × 11–13.5

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* The generic name *Lachnosterna* is adopted throughout this paper in preference to *Phyllophaga* on the authority of Mr. G J. Arrow, an expert on the group. Mr. Arrow states (Bull. Ent. Research, XI, 1920, p. 189).

"In recent American works on this group of beetles the generic name *Phyllophaga* has been adopted. This name was introduced by Harris in 1826. . . . It is, however, a *nomen nudum*, accompanied by no description, and is therefore upon the same footing as the numerous catalogue names printed by dealers and others, to which obviously no scientific value can be attached."

Messrs. C. W. Leng and A. Mutchler, of the American Museum of Natural History, employ the name *Lachnosterna* in their standard Catalogue of West Indian Coleoptera (Bull. Amer. Mus. Nat Hist., XXXIII, Art. XXX, 1914, p. 440).

** Mr. Arrow (*ibid*) includes *Phytalus* in *Lachnosterna*, and gives good reasons for doing so, but in the present paper the writer prefers to use a nomenclature conforming to the American catalogue above referred to. (Messrs. Leng and Mutchler separate the two genera, and include *apicalis*, Blanch. in *Phytalus*.)

This species is found all over the eastern part of Porto Rico on both north and south coasts, and in the interior; its most westerly limit appears to be near Ponce on the south coast. It is the one causing the greatest actual loss to the Island's cane industry, and the one against which the greatest effort has to be made at control.

The natural enemies of *L. portoricensis* are chiefly predators, among which birds, lizards, and carnivorous beetles are the most useful. Two parasites, both of them flies (Diptera) of the family Tachinidae, attack the adult in the moister parts of the Island; these flies are *Cryptomeigenia aurifascies*, Walton, and *Eutrixoides jonesii*, Walton. Another fly, *Sarcophaga robusta*, Aldrich, has been bred from the grubs of *L. portoricensis;* this parasite also attacks caterpillars, grasshoppers, and occasionally the *changa* (*Scapteriscus vicinus*, Scudd.) Hitherto no wasp parasites of the larva have been known to occur in Porto Rico, but the writer has been able to demonstrate that the third-instar grubs are the host of the Scoliid wasp *Dielis* trifasciata*, F., and are also liable to attack by *D. dorsata*, F. and *D. pyrura* Roh. The second-instar grubs have been found to serve as host for another Scoliid, *Elis xanthonotus*, Roh., but it is not known for certain whether they are normal host of that parasite. It is not improbable that *L. portoricensis* is the host of *Elis ephippium*, F., a wasp closely related to *E. xanthonotus*.

	Maximum	Minimum	Average
Life-cycle in days:			
Egg stage	15	12	13.5
Larva, 1st instar	40	26	32
Larva, 2nd instar	93	43	61
Larva, 3rd instar	174	164	169
Pupa stage	23	20	21.5
Total life cycle, from egg to adult	345	265	297

2. *Lachnosterna vandinei*, Smyth

Dimensions in millimeters:	
Adult	17–22
Egg	2.97 × 1.7
Larva, 1st instar	6–17
Larva, 2nd instar	16–28
Larva, 3rd instar	27–45
Pupa	23–27 × 10–12

L. vandinei is the analogue in the west of Porto Rico to *L. portoricensis* in the east, and is responsible for considerable damage to sugar-cane on properties situated between Mayagüez and Ponce. Nothing has been recorded in Porto Rican literature as to its larval parasites, but the writer believes that these, as well as the parasites of the adult and the predaceous enemies, are the same as those of *L. portoricensis.*

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* See footnote on page 85

	Maximum	Minimum	Average
Life-cycle in days:			
Egg stage	16	10	14
Larva, 1st instar	59	17	36.5
Larva, 2nd instar	103	26	47
Larva, 3rd instar	226	78	183
Pupa stage	26	17	21.5
Total life-cycle, from egg to adult	430	148	302

3. *Lachnosterna guanicana*, Smyth

Dimensions in millimeters:	
Adult	13–17
Egg	2.05 × 1.2
Larva, 1st instar	4.5–12
Larva, 2nd instar	12–20
Larva, 3rd instar	20–32
Pupa	18 × 7.9

This species, as its specific name implies, is distributed around the Guánica section, where it was estimated by Mr. Smyth to be one-tenth as abundant as *L. vandinei.* It parasitic enemies, if any, are unknown, but it is probable that it is attacked by the same predators that assist in controlling *L. portoricensis* and *L. vandinei.* There is some suggestion, in the writer's opinion, that this grub is the host of a species of *Tiphia* which has been found in the Guánica district.

Lachnosterna guanicana is almost identical in size with a Barbadian Melolonthid, *Phytalus smithi,* Arrow, and there can be little doubt that it should lend itself to control by a Scoliid wasp, *Tiphia parallela,* Sm., which keeps down the numbers of *P. smithi* in Barbados.

	Maximum	Minimum	Average
Life-cycle in days:			
Egg stage	19	11	13.5
Larva, 1st instar	35	13	24
Larva, 2nd instar	39	23	31
Larva, 3rd instar	221	138	178
Pupa stage	(22)	(22)	(22)
Total life-cycle, from egg to adult	336	207	268.5

4. *Phytalus apicalis*, Blanchard (*insularis*, Smyth)

Dimensions in millimeters:	
Adult	9.5–11.5
Egg	1.45 × 0.90
Larva, 1st instar	3.5–8
Larva, 2nd instar	8–14
Larva, 3rd instar	14–22
Pupa	9 × 11

The adult of *P. apicalis* is commonly called the "Little May-Beetle", and is the smallest of the Porto Rican Melolonthids. It will be seen that in size the mature grub of this species is similar to the average 2nd-instar grub of either *L. portoricensis* or *L. vandinei*, with which it can readily be confused. Mr Smyth records the following differences in the dimensions of the head in these grubs:

Width of head in 2nd instar *L. portoricensis*	3.45 mm.
Width of head in 2nd-instar *L. vandinei*	3.32 mm.
Width of head in 3rd-instar *L. apicalis*	2.63 mm.

Phytalus apicalis is distributed all over Porto Rico, and its larvae often occur in company with those of the larger Melolonthids. Mr. Smyth states that this species is less common in the Guánica district than *L. vandinei*, but on the region of the south coast familiar to the writer, extending from near Fortuna to Guayama, it is the commonest species, being on an average two or three times as abundant as *L. portoricensis*. Owing to its small size, *Phytalus apicalis* is not generally reckoned as being of great importance as a cane pest, but, on the south coast its dimensions are amply compensated for by its great numbers, ranking the species as one of decided economic importance.

In addition to the usual predators, *Phytalus apicalis* is attacked in Porto Rico by the Scoliid *Elis haemorrhoidalis*, F.; mortality through this agency sometimes amounts to as high as 65 per cent The wasp is controlled by a hyperparasite, *Anthrax gorgon*, F. (Bombyliidae).

Life-cycle in days:	Maximum	Minimum	Average
Egg stage	12	10.5	11.5
Larva, 1st instar	39.5	21.5	30
Larva, 2nd instar	54	37	45.25
Larva, 3rd instar	197	191.5	194.25
Pupa stage	(20)	(20)	(20)
Total life-cycle, from egg to adult	322.5	280.5	301

5. *Strataegus titanus*, Fabricius

Dimensions in millimeters:

Adult	35–45
Egg	3–4.5 × 3.5–5.2
Larva, 1st instar	8–25
Larva, 2nd instar	25–45
Larva, 3rd instar	45–70
Pupa	30 × 40

The adult of this species is known as the "Sugar-cane Rhinoceros Beetle", on account of the fact that the head of the adult male is provided with a short up-turned "horn", suggesting that of the animal after which it is named. Another species (*S. quadrifoveatus*, P. de B.) occurs in Porto Rico, which seldom if ever is found in canefields, confining its attack for the most part to coconut palms. *S. titanus* normally feeds in decayed or decaying tree trunks, but owing to the rapid deforestation of the southern part of the Island, *S. titanus* has adapted itself to a diet of sugar cane, upon the subterranean portions of which its larvae feed. It is open to doubt whether perfectly healthy cane-stools are attacked by *Strataegus*, it being more probable that this insect follows on after the stools have been injured by either *Lachnosterna* or *Phytalus*, or by lack of moisture. The fact remains, however, that one maturing larva of *S. titanus* can completely ruin a cane-stool, necessitating its replanting, and the species should consequently be regarded as one of the major sugar-cane pests of Porto Rico. In several instances the writer has found as many as five fully grown larvae of *S. titanus* in one stool of cane in heavily attacked localities.

No insect parasites have been recorded as attacking *Strataegus titanus* in Porto Rico, but Mr. G. N. Wolcott remarks that the rare black wasp *Dielis atrata*, F.,* on account of its large size, cannot have any host of sufficient size for its development other than the species of *Strataegus*, an observation that has now been confirmed experimentally by the writer by means of living *D. atrata* brought in from Santo Domingo; it has been found that these wasps readily parasitize the third-instar larvae of *S. titanus*, and therefore should be regarded as very desirable to firmly establish in this island, which can be accomplished by means of introductions of the wasp in large numbers from the Dominican Republic, followed on by breeding work this end.

Mr. Smyth states, with reference to *S. titanus*, that—

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* See footnote on page 91

> "Besides Porto Rico, this beetle has been recorded as occurring in Cuba, Jamaica and the Virgin Islands. It has also been collected in Vieques and in Santo Domingo."

The writer was not able to ascertain which species of *Strataegus* (for there are several) is the normal host of *Dielis atrata* in Santo Domingo, but *S. titanus* was collected in the same localities where *D. atrata* was found.

Life-cycle in days:	Maximum	Minimum	Average
Egg stage	21	15	17
Larva, 1st instar	72	24	40.5
Larva, 2nd instar	85	43	72
Larva, 3rd instar	282	137	199
Pupa stage	29	22	24
Total life-cycle, from egg to adult	289	241	352.5

6. *Ligyrus tumulosus*, Burmeister

This Dynastid, although not actually a serious pest of sugar-cane, is deserving of inclusion here, owing to its inter-relations with certain parasites of the noxious species of *Lachnosterna*.

The adult, which may be known as the "Rough Black Hardback", occurs commonly, though seldom abundantly, throughout the year, the species having a short life-cycle (see below), with three or four generations annually. The eggs are deposited in soil rich in organic matter, or in stable manure, upon the humus of which all stages of the larvae feed, although the more mature grubs will consume the decaying portions of old cane stools, rotten wood, etc., and are sometimes so abundant in the old stools left in the "banks" between the rows of growing canes that damage to the crop is frequently—though seldom correctly—attributed to them. Under exceptional conditions, such as periods of extended drought, the grubs are driven to attack the underground portions of growing canes, owing to the absence of other moisture-bearing food, but such occurrences are so rare that no special control efforts are necessary against *L. tumulosus* in Porto Rico. It frequently happens that laborers are encouraged to collect the grubs of this species, being paid for them at the same rate as if they were *Lachnosterna;* planters should learn to distinguish between the harmful *Lachnosterna* and the comparatively harmless *Ligyrus*, as considerable sums of money could thereby be saved, or better still, devoted to more useful methods of insect control work.

Ligyrus tumulosus occurs commonly in the island of Barbados, and the writer found some examples* of what appear to be this species at Central Romana in the Dominican Republic.

In Porto Rico, as well as in Barbados, the third-instar grubs of *L. tumulosus* are very heavily parasitized by the Scoliid *Dielis dorsata,* F., a wasp that also occurs in Brazil and the Guianas, in which countries it attacks species of *Ligyrus* (*L. ebenus,* Burm. and *L. gyas,* Er.). In Porto Rico *D. dorsata* is so abundant that it would surely be able to exterminate *Ligyrus* were it not itself heavily hyperparasitized by certain flies, chief among which is the Bombyliid *Anthrax lucifer,* F., in spite of which, however, the wasp succeeds in periodically reducing the numbers of *Ligyrus* grubs in each locality to almost the zero point.

Life-cycle in days:	Average
Egg stage	13
Larva, 1st instar	13
Larva, 2nd instar	15
Larva, 3rd instar	27
Pupa stage	14
Total life-cycle, from egg to adult	82

Two other Dynastids—*Dyscinetus barbatus,* F. and *D. trachypygus,* Burm.—occur in Porto Rico, but neither of them seems to be associated to any great extent with the sugar-cane crop of the Island; the larvae of *D. trachypygus,* however, have been recorded by Mr. Smyth as damaging cane roots. The species are worthy of mention, however, as in British Guiana others of the same genus (*D. geminatus, F.* and *D. bidentatus,* Burm.) act as hosts of *Tiphia parallela,* a wasp that it is very desirable to introduce into Porto Rico, and for the establishment of which the grubs of the native species of *Dyscinetus* might very well serve.

SEASONAL DISTRIBUTION OF PORTO RICAN MELOLONTHIDAE

A glance at Fig. 2 will serve to show how the various stages of *Lachnosterna* are distributed throughout the year. The adults (*caculos*) commence to appear in numbers early in April, and continue to occur abundantly until towards the end of August, being most abundant in June and July. There are, however, always a few

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* These have since been sent to the Imperial Bureau of Entomology, London, and, though not specifically determined, were found to be distinct from the Porto Rican *L. tumulosus*

PLATE III

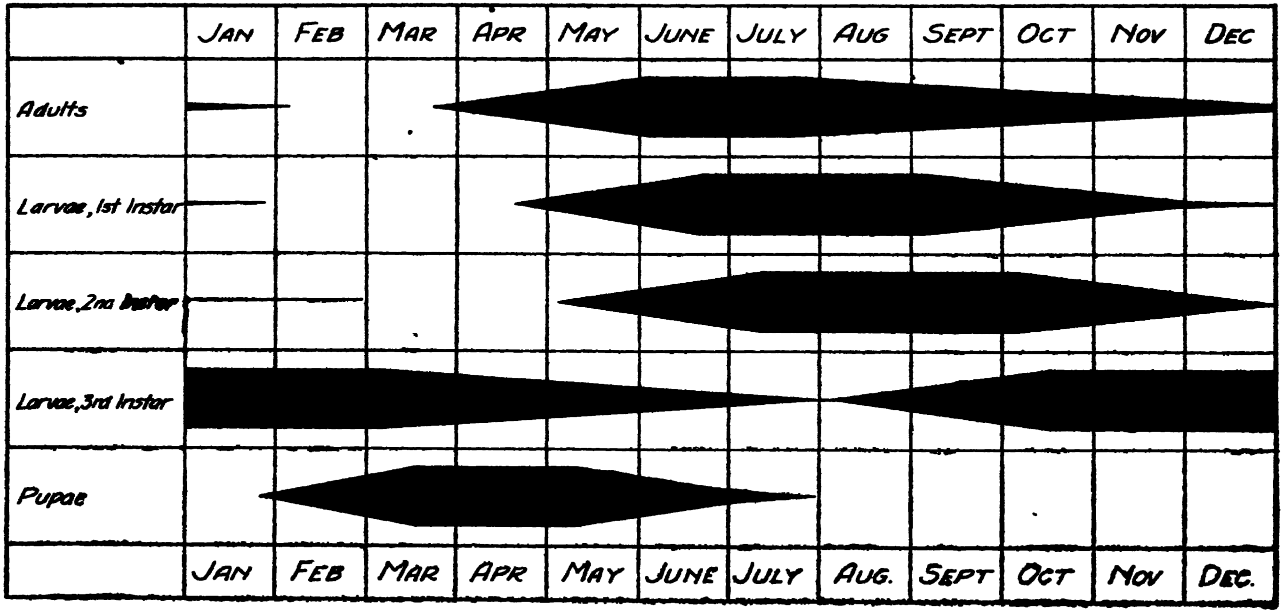

FIG. 1.—Seasonal Distribution of Porto Rican Melolonthidae. (Del. D. Wilson)

(NOTE *The thickness of the bar denotes relative abundance*) "stragglers" which remain until sometimes as late as January. The first-instar grubs are consequently most often met with in the cane-fields from the middle of April until early in September, while the second-instar larvae are seldom found before the first weeks of May, continuing to be common until early in October. The destructive third-instar grubs commence to make their appearance during August, reaching their maximum abundance from November until February, gradually diminishing in numbers until in June and July very few can be found. It will be seen that the period of the maximum abundance of the third-instar, the stage most responsible for damage to the crop, coincides with the most critical stage in the growth of late *primavera* cane, which generally suffers more from grub attack than does *gran cultura.* It is not yet known why *caculos* select certain fields for egg laying, but it is reasonable to suppose that the chief factors concerned are (i) the proximity of trees upon the foliage of which the adults feed, and (ii) the height of the cane, for they do not appear to oviposit to any great extent in fields of canes over three feet in height.

THE CONTROL OF CANE-GRUBS IN PORTO RICO

Since 1911 the problem of the control of cane-grubs has constantly received the attention of the entomologists of the Experiment Stations in Porto Rico. Through the failure to obtain results with certain wasps that were introduced from the United States way back in 1911 and 1913,* this line, which the writer considers the most promising angle of attack against the pest, has been practically abandoned, and attention turned to the possibilities of effecting the control of white grubs by means of fumigants applied to the soil. Mr. Wolcott has experimented in detail with several promising substances, including carbon bisulphide and its emulsion, calcium cyanamide, and para-dichlorobenzene (P.D.B.), none of which gave the desired results, or, doing so, were found too expensive to apply upon a plantation scale. At Aguirre the writer has experimented with P.D.B. and also "Cyanogas" (calcium cyanide), a sample of the latter product being received from the American Cyanamid Company, 511 Fifth Avenue, New York City. The experiments were carried out in heavily infested B.H. 10(12) *gran cultura* cane in which an average of thirty-five grubs occurred around each stool.

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* See pages 100–101.

It was found that either of the substances tried was effective in killing up to eighty-five per cent of the grubs when applied at the rate of one ounce per stool, the chemical being lightly scattered over the soil for a radius of nine inches from the center of each stool; the soil was slightly broken both before and after the chemical was applied, and the application was followed by a moistening of the soil with irrigation water. The results obtained suggest the desirability of further trials on properties where fumigation is considered likely to prove a practicable proposition.

No doubt, where large numbers of grubs occur in limited areas, some method such as the above might be found economical, but the expenses should be chargeable to the immediate crop of the areas so treated.

For the control of white-grubs where they occur over wide areas, other means must be found more practicable, especially to the small farmer, and in consequence, the only attempts that are now being made at control are the collection of grubs when fields are being ploughed, and the collection of adult beetles during the epochs of their maximum abundance and even these oparations cannot be said to be done upon anything like a satisfactory scale, partly owing to the independence of the laboring classes in many districts, but also due to a spirit of *laissez-faire* prevailing among many elements of the planting community.

On the larger properties, especially upon the south coast, the work of collecting *caculos* is included in the regular routine operations of the field administration, but even so the collections are made intermittently and more or less at random, no really systematic campaign being considered practicable under existing conditions.

Mr. E. H. Barrow points out in a recent publication that the administration of one of the larger concerns operating on the south of Porto Rico spent approximately $15,000 upon some six million grubs and four million adults of *Lachnosterna* during the five years 1919 to 1923 inclusive. Such collections, although aparently large, represent no more than a "drop out of the bucket". Though a certain amount of good must necessarily follow, it is felt that such is out of all proportion to its cost. To obtain any real benefits through a reduction in the annual status of the pest, the collections should be carried out upon a much larger scale than they are at present, and over large areas simultaneously.

To be economical, when a continuous *annual* (as constrasted with a *capital*) expenditure upon insect-pest control is made, such should at least be equal to the benefits obtained the next year; otherwise there is an actual loss through the transaction. With sugar at, say, five cents, the expenditure quoted above represents an equivalent value to approximately 1,350 tons of cane; that is to say, the destruction of two million *Lachnosterna* annually should have caused a saving of 270 *tons of cane* each following year to justify its cost, which we venture to doubt was actually the case.

For comparison it may be of interest to record that when the canefields of Mauritius were seriously threatened some years ago through the ravages of *Phytalus smithi*, a Melolonthid that was accidentaly introduced into that Island from Barbados, the Government issued an order in 1915, which reads:

> "PLANT DISEASE PROCLAMATION (AMENDMENT)
>
> "It shall be lawful for the Director of Agriculture, when the numbers of beetles are in great abundance, to require any proprietor, manager, or lessee of land to furnish, for collection of insects upon their lands, one-third of the total number of their engaged labourers per night; and if these labourers are not furnished an equivalent number of men may be employed by the Director of Agriculture and the charge made against the proprietor, manager or lessee."

As a result of this somewhat stringent (though necessary) measure, the following numbers of adult *Phytalus* were obtained:

1915–16	42, 511, 241
1916–17	72, 292, 689
1917–18	70, 035, 663
1918–19	71, 119, 278
1919–20	30, 969, 504
Total, 1915–20	286, 928, 375

The writer considers that unless results like the above can be accomplished by hand collection, a far greater value could be obtained from money spent upon cane-pest control were such sums devoted to fostering and advancing the status of the native parasites of the Island, and in securing other species of these useful insects from abroad.

NATURAL ENEMIES OF CANE-GRUBS IN PORTO RICO

A. Predators.

Although it would be difficult to artificially increase the numbers of the insect predators of Lamellicorn larvæ, a knowledge of them and of their habits is of the greatest importance.

The most useful and generally distributed predator upon white-grubs in Porto Rico is undoubtedly the Elaterid beetle, *Pyrophorus luminosus*, F., known as the "*cucubano*", the elongated yellow larva of which can be found in nearly all fields where grubs occur, feeding upon them in all their stages. The writer had one of these carnivorous larvae kept in captivity and during one week it destroyed twenty-five full grown *Lachnosterna* grubs, and it has been recorded that in Queensland a larva of the Elaterid *Agrypnus mastersi*, Pascoe, killed and consumed 230 cane-grubs in 17 months.

It is a matter for regret that on many sugar estates in Porto Rico no discrimination is made between this useful insect and the grubs which it destroys, although it in no way resembles a white grub, for numbers of *cucubanos* are collected by the boys who search for grubs and are paid for at the same rates as the latter. Unless laborers (and those of higher responsability, too) can be taught not to destroy such beneficial insects at these beetle larvae, it would be better not to do any collecting at all, for more harm is done than good. Owing to their rapid movements, it seldom happens that these Elaterid larvae fall prey to blackbirds, which in any case would probably reject such unsavory morsels.*

The larvae of the carnivorous Carabid beetle, *Calosoma alternans*, F., rank next in importance, but they are not so frequently seen as those of *Pyrophorus*.

An Asilid fly, whose larva is also carnivorous, is reputed to attack white-grubs in Porto Rico; the writer has met with it upon two occasions in grub-infested cane-fields near Aguirre. These large Diptera are of some importance in the United States, as controlling agents of *Lachnosterna*, but in Porto Rico their value seems almost negligible.

Vertebrate enemies of cane-grubs include birds, of which the most important as a controlling agent is the Porto Rican Blackbird (*Holoquiscalus lugubris*, Cassin), large numbers of which follow ploughing machines, picking up any grubs that are exposed; by examining fields at ploughing time, however, one finds that numbers of the grubs escape, and a fair percentage of those collected by the birds were already killed or injured by the machines passing over them.

Mr. Alex. Wetmore, in his excellent treatise, "The Birds of Porto

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* Mr. Wetmore records no instance where *Pyrophorus* was found in the stomach-contents of Porto Rican birds, even when the latter had been feeding in fields heavily infested with cane-grubs, and where in all probability the Elaterids occurred in numbers

Rico", makes the following observation, worthy of attention: "That birds need shelter as well as protection will not be questioned, and owners of plantations should look carefully to providing this if it is not already present. A long level stretch of cane or tobacco, with not a tree or other obstruction to break its continuity, while a pleasing sight to the agriculturist, offers little encouragement to the bird in search of shelter and food. A similar stretch of cultivated land, with lines of symmetrical royal palms or coconuts along roadways and dense clumps of graceful bamboos adorning the borders of streams, while not losing an iota of its productiveness, will gain an esthetic charm and beauty and provide an attractive feeding ground for birds which will more than repay the owner in the great numbers of injurious insects they consume." The writer is strongly advocating the planting of more royal palms in certain *haciendas* of the Aguirre properties, as the crowns of these trees are the favorite nesting sites for blackbirds, and it is believed that an increase in the numbers of palms will in time lead to the augmentation of the numbers of these useful birds.

Lizards exert an influence upon the status of the grub pest, and Mr. Wolcott records two species, *Ameiva exsul,* Cope and *Anolis cristatellus,* Dum. & Bib., as being known to consume Lamellicornia in Porto Rico. Among the reptile class, however, the Island sadly needs toads, to which Mr. Wolcott draws attention in the following words: "Although the small tree-toads or *coquís* are abundant in Porto Rico, there are no large nocturnal native toads large enough to eat May beetles. Such large toads are found in most of the other West Indies and on the mainland, and keep the number of May Beetles and their larvae, the white-grubs, so reduced that they are seldom pests of cultivated crops." From time to time importations of small numbers of toads into Porto Rico have been made; it is hoped that these will breed, and in any case it is desirable to supplement their numbers by obtaining further supplies from Santo Domingo and elsewhere, in order that each plantation can have its own place for rearing them artificially for distribution, small "toaderies" being established here and there throughout the properties. The importation and establishment of toads should be undertaken by the sugar-cane growers of Porto Rico as their first measure in any campaign against *Lachnosterna* by means of its natural enemies.

B. Parasites.

In addition to a mortality due to attack by parasitic fungi and bacterial diseases, the larval and adult stages of the Lamellicornia succumb to a variety of insect parasites, both internal and external in habit. Several species of these parasites are known to occur in Porto Rico, but none of them, for reasons already explained, are sufficiently abundant to effect any marked control over the Melolonthidae and Dynastidae that attack sugar-cane.

Apart from the wasp-parasites about to be dealt with in detail, there are a variety of fly-parasites upon both larvae and adults of the Melolonthidae, and some of these might well be introduced into Porto Rico to assist the two species (*Cryptomeigenia aurifascies*, Walton and *Eutrixoides jonesii*, Walton) already occurring here. Owing to the mode of life of these flies* and the difficulties attendant upon their propagation by artificial means, large numbers would have to be introduced to effect the establishment of foreign forms.

The most important and generally effective enemies of the Lamellicornia in all parts of the world are the "digger-wasps" of the family Scoliidae, which prey upon the beetle larvae, and it is through their agency that the writer believes the control of Porto Rican cane-grubs will ultimately be obtained.

THE DIGGER WASPS (SCOLIIDAE)

The family consists of a large number of fossorial Hymenoptera which are exclusively parasitic upon the larvae of Lamellicorn beetles, and when one has become familiar with their general aspect, these wasps can readily be distinguished from all other kinds. The characteristic feature of the Scoliidae is the presence of a constriction at the junction of the (apparently) first and second abdominal segments. The females differ considerably from the males both in dimensions and in coloration, some species of Scoliids, *e.g.*, *Dielis dorsata*, F., being sexually dimorphic. The females are stout-bodied wasps, the body being broadest at the posterior end of the thorax and the middle of the abdominal region; the legs are rather short, thickset, and are covered with a heavy armature of short spines which aid the wasp in its digging operations; many parts of the body are covered with a thick velvety pubescence. The males, on the other hand, are slender and are without the conspicuous spines upon the limbs; they are easily distinguished from the females by

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* These flies oviposit upon the exposed part of the body of the beetle, when its wings are expanded during flight after dark.

the length of their antennae, which generally equal nearly the length of the body, whereas those of the females are quite short, scarcely equalling the length of the head. In size the Scoliids vary from barely three quarters of an inch in wing expanse (*Tiphia,* etc.) to those with a span exceeding three inches (*Dielis atrata*); the majority, however, have a wing spread of between an inch and an inch and a half. There is considerable variation in color among the different species, some being entirely black, others black with yellow bars across the thoracic and abdominal segments, while not a few of them have clearly defined portions showing bright red, due to pigmentation of either the integument or of the pubescence, or both. The wings of some species are pigmented to show blue or purple reflections when viewed in certain lights, being transparent white or yellow, or translucent blackish ("smoky"), by transmitted light; many species have wings without these iridescent reflections.

The family includes several thousand species distributed in all parts of the world, the number of species in any locality being more or less in proportion to those of the Lamellicornia upon which they breed. Dr. F. X. Williams, an authority upon the group, remarks that the diversity in the Lamellicorn fauna of any district serves as an index to the Scoliidae likely to occur there. Many of these wasps parasitize grubs of little or no economic importance, but, on the other hand, large numbers of potential pests are kept entirely under control through their agency. Some of the Scoliids specialize upon one particular species of grub, while others are not so discriminating, having a wide range of hosts. A typical example of the latter type is *Tiphia parallela,* which attacks the Melolonthid *Phytalus smithi* in Barbados and species of Dynastids (*Dyscinetus,* etc.) in South America. These naturally adaptable species are on the whole more likely to prove useful to Porto Rico than the more specialized types, although some of the latter, when deprived of their normal hosts, will turn their attention to other species of grubs. An example of this kind is *Dielis dorsata,* which normally parasitizes the Dynastid *Ligyrus tumulosus,* but which will work upon such Melolonthids as *Lachnosterna* in the absence of *Ligyrus.*

The Scoliidae consist of several genera, of which *Dielis, Elis,* and *Tiphia* are the most likely to include species which may prove beneficial to Porto Rico.

HABITS AND LIFE-HISTORY OF THE SCOLIIDAE

During the early hours of sunshine, from about eight o'clock until eleven o'clock in the morning, the females can be seen refreshing themselves with the nectar of certain flowers*. At mid-day they disappear underground, where they search for their prey. The males, on the other hand, can generally be found above ground at all hours of the day, flying with a series of rapid zig-zag motions in the vicinity of places favored by their mates, settling now and then to imbibe the nectar from wild flowers. A very curious habit exhibited by the males of some genera of Scoliidae is that of congregating together in large numbers towards the late afternoon upon the stems and leaves of wild vegetation; sometimes the males of the common *Dielis dorsata* can be seen in hundreds upon the leaves of the iron-weed or *escovilla* (*Sida carpinifolia*, L.) that abounds in the vicinity of canefields, while those of *Elis haemorrhoidalis*, another common Scoliid, may sometimes be seen in large clusters resting upon the leaves and flowering spikes of the pigweed or *bledo* (*Amaranthus spp.*). In Santo Domingo the writer has seen the branches of young guácimas (*Guazuma guazuma*, L.) hanging low with the weight of thirty or forty males of the large black *Dielis atrata*. Dr. Williams remarks "They may assume odd positions on these weeds, which they grip with their jaws and legs or with the jaws only". The writer thinks that the habit may be some sort of response to the social instinct derived from their ancestors.

The life-history of the Scoliidae constitutes one of the most interesting phases of Insect Life, and its study is fascinating in the extreme.

The female Scoliid would appear to possess extremely powerful olfactory and auditory senses for the location of her prey, as this is carried on out of sight, sometimes at a depth of two feet or more below the surface of the ground. When a grub has been found, the wasp gets busy around it, and, after a short time spent in feeling over it with her very active antennae, proceeds to sting it in one of the large nerve-ganglia that control the locomotor muscles, so that the grub is rendered completely immobile, yet still alive; in this way the mother-wasp insures a supply of fresh food for her offspring, and would seem to have arrived at a higher stage in evolution in this respect than the social wasps (*Vespidae*) that have to bring in freshly-killed prey to the young larvae in the nest, which food, unless immediately consumed, would rapidly decompose.

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* This refers to the strictly anthophilous types Some Scoliids, chiefly the species of *Tiphia*, do not frequent flowers, but are attracted to the sweet secretions (honey-dew) of scale-insects (Coccidae) and plant-lice (Aphidae) on the leaves of trees or other vegetation.

In the glass jars (Fig. 13, A) employed for rearing Scoliidae artificially the female wasp can be seen to drag the helpless grub down to the bottom of the jar, where a space is cleared around it, the wasp packing the soil above the grub's body to form a roof, the whole forming an oval cell with the paralysed grub resting upon its back in the bottom of the hollow, thereby giving ample room for the wasp's movements during the process of oviposition. It is not known whether under actual field conditions the wasp makes the cell at the point in the ground where she first located and stung the grub, or whether the latter is dragged to a lower level through the surrounding medium. When the wasp is satisfied with the preparation of the home for her future offspring, she wanders around the grub, feeling over it with her legs and antennae, adjusting a limb here and there, or removing a fragment of dirt from its body, and after a few minutes spent in this manner, she adjust her body to the length of that of the grub, grasping the up-turned undersurface of the thorax with her front two pairs of legs, and its head with her jaws, and, bending her flexible abdomen down upon the venter of the grub, moves it about searching for the exact spot (which appears to be free from setae) for the deposition of the egg, which latter operation occupies about a minute. (The writer has several times watched the whole process through the glass walls of the rearing jars). The egg is cylindrical, slightly curved, and has rounded ends; the ratio of its length to its greatest breath is approximately as 4:1. The egg is laid with its longitudinal axis at right angles to that of the grub (Fig. 5, A & B), being glued into position by a fluid secreted by the wasp during the act of laying it. The foregoing applies to wasps of the genus *Dielis,* and some species of *Elis.* The habits of *Elis xanthonotus* are similar; except that the egg is laid towards the posterior end of the grub's abdomen, and flat across the surface of the grub's body, instead of at right angles to it. The species of *Tiphia* do not completely paralyze the host, which recovers from the effect of the sting after the deposition of the egg, and during its crawling movements the latter is sometimes rubbed off; *Tiphia* lays its eggs upon the back of the grub, across the thorax, just behind the head.

The entire operation from the time the grub is first located until the egg has been laid occupies about two hours. It is not known, and of course impossible to ascertain, how many grubs are parasitized by a female in the course of a day in a state of nature, but under artificial conditions the writer has been able to obtain three eggs from one wasp within the twenty-four-hour period with one of the smaller *Dielis;* two per day however, is a good average for breeding purposes. When the wasp has completed the deposition of the eggs she takes a final look around and departs in search of another grub.

The eggs do not require any great length of time before they hatch; those of *Elis haemorrhoidalis* and *E. xanthonotus* hatch within 32 hours of being laid, while those of *Dielis atrata* take 72 hours for their development; the eggs of *D. dorsata, D. trifasciata,* etc., require an intermediate period of about 48 hours. The empty egg-shell is pushed aside by the newly-hatched wasp-larva, after which the latter buries its mouth-parts into the body of the host and the consumption of the internal parts of the grub's body commences.

EARLY STAGES OF SCOLIIDAE

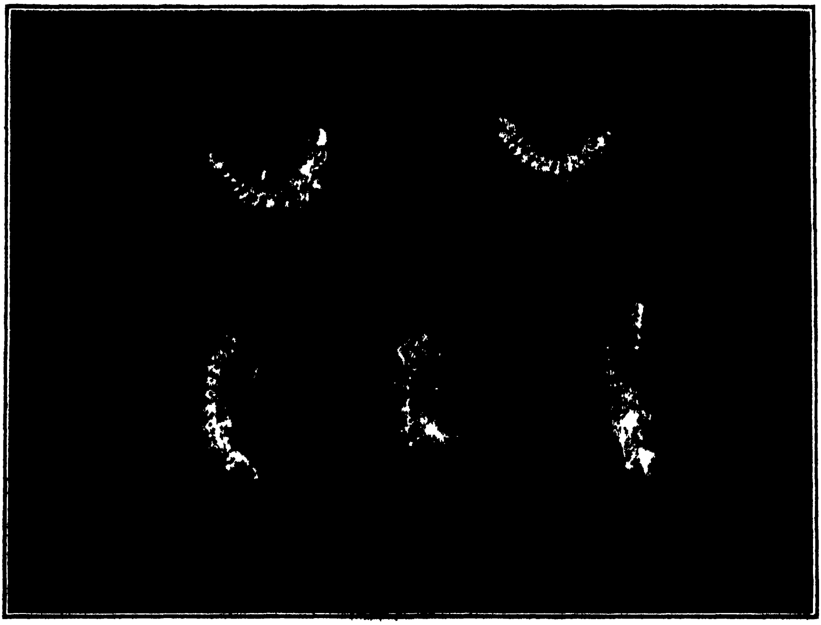

FIG. 5.—Eggs and Larvae of *Dielis trifasciata*, F. upon grubs of *Lachnosterna portoricensis*. Sm. (natural size). (Photo. Rodríguez Serra, Ponce)

A B—Eggs (lateral aspect)
C—Larva, 3 days old (lateral aspect)
D—Larva, 4 days old (lateral aspect)
E—Larva, 5 days old (dorsal aspect)

With unfailing instinct the young wasp avoids injuring those parts of the host's anatomy to which damage would prove fatal. It is probable that an ecdysis occurs before the larva is half-grown, but such has not been observed by the writer. With the increase in the size of the wasp larva there is a corresponding diminution in the size of the host, and when the former is fully fed, nothing remains of the latter but an empty shrivelled skin with the head and legs attached. Wasp larvae in an early stage of development, on being removed from a grub, will commence to feed upon another provided the latter's integument has been pierced. A curious habit of these larvae when nearing maturity is that of ejecting a milky fluid from the posterior extremity when disturbed; this fluid can be squirted to a distance of several inches.

EARLY STAGES OF SCOLIIDAE

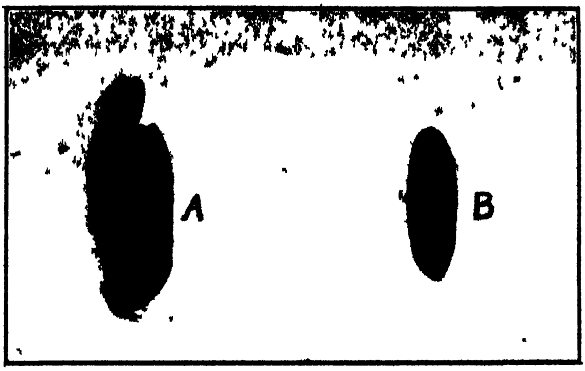

FIG. 6.—Cocoons of Scoliidae (natural size)
(Photo. H. L. Dozier)

A—*Dielis* type adult emerges by means of hinged lid at one end
B—*Elis* type adult emerges by means of a ragged hole bitten in one side

Scoliid larvae are glistening white and they appear to be slimy; at first they are pear-shaped or almost globular (Fig. 5, C), but later they become elongated and decidedly maggot-like (Fig. 5, D and F.) The fully-grown larva of the smaller Scoliids (*Elis* and *Tiphia*) is about half an inch in length, the larva of the medium-sized species of *Dielis* about an inch, and that of *D. atrata* one and a half inches long when mature. The time spent in the larval stage, feeding upon the paralyzed host, has been ascertained to be from three to four days in the case of *Elis*, seven days in the case of the smaller *Dielis*, and fourteen days in the case of *D. atrata*. The egg and larval stages are of longer duration in cool weather than in warm, and frequent changes of temperature seem fatal to the Scoliidae in all their early stages.

The wasp-larva, upon completing its development, constructs a neatly made cocoon around itself, the cocoon being formed in two layers, the inner one smooth and shiny on the inside, the outer layer coarser and rough in texture. Pupation occurs within the cocoon, and from four to six weeks are spent in this stage, after which the mature sexually-perfect adult wasp emerges; the time spent in the cocoon depends upon the temperature prevailing. Wasps of the genus *Dielis* emerge by biting a neat lid out of one end of the cocoon, the lid being hinged so that it can be pushed aside by the emerging wasp (Fig. 6, A); *Elis* and *Tiphia* merely gnaw a ragged hole in one side of the cocoon, through which aperture the wasp crawls out (Fig. 6, B).

NATURAL ENEMIES OF THE SCOLIIDAE

Although the Scoliidae suffer to some extent through being preyed upon by vertebrate animals (birds and lizards), and certain carnivorous insects chiefly predacious bugs of the family Reduviidae, as well as spiders, it is the insect hyperparasites that are so largely reponsible for keeping down their numbers; indeed, were it not for these hyperparasites, it is doubtful whether any of the Lamellicornia could ever become pests, so great are the multiplicative powers of the Scoliidae.

Apropos, the following extract from a paper by Dr. J. F. Illingworth, upon the natural enemies of cane-grubs in Queensland, may be of interest:

> "It would be interesting to know what percentage of the Scoliids are destroyed by these parasitic enemies, but unfortunately this is a phase of the problem on which we have no data. Yet, when we consider the comparative abundance of the wasps that are known to prey upon grubs in our cane areas, we are forced to conclude that a very large majority of them must succumb to natural causes. Otherwise, with their prolific reproduction, they would be able to hold our cane-beetles in check with no assistance."

There are three main types of hyperparasites upon fossorial Hymenoptera, species of each of which are responsible for checking the increase of the Scoliidae: (i), the Bombyliid flies; (ii) the Tachinid flies; and (iii), the Rhipiphorid beetles.*

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* In the United States it is recorded that a Scoliid of the genus *Elis* is hyperparasitised by members of a fourth group—the Mutillid wasps

THE BOMBYLIID FLIES

A specimen of *Anthrax lucifer*, F., a typical Bombyllid, is illustrated in Fig. 7, A, and the figure serves to show the general aspect of one of these flies. The family includes many hundreds of species distributed over most parts of the world, several of which are hyperparasites upon fossorial hymenoptera. The Bombyliid adults are among the most rapid of all insect fliers, and are commonly to be seen darting or hovering over the surface of the soil, especially in sandy locations, as well as haunting the vicinity of the nectar-bearing flowers that are so attractive to the wasps whose early stage they parasitize.

HYPERPARASITES OF SCOLIIDAE

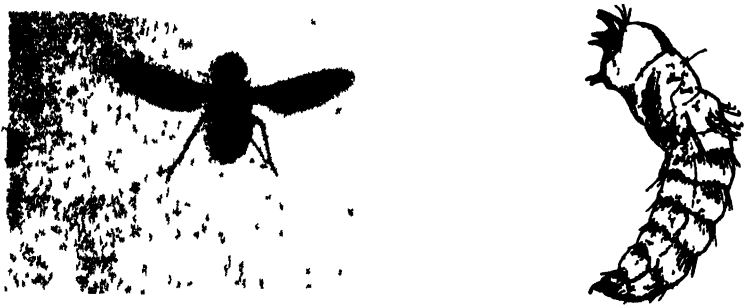

FIG. 7.—Bombyliidae

A—Adult of *Anthrax lucifer*, F, a typical Porto Rican species (natural size) (Photo H L Dozier)
B—Pupa of one of these flies (Del H E Box from Davis)

So far as the writer is aware, nothing is known of the mode of life of these flies during their early stages, but the empty pupa cases are very often to be found protruding from punctured Scoliid cocoons. Large numbers of individuals of the commoner species of Scoliids in all stages have been examined by the writer, and, although many cocoons were found with the empty Bombyliid pupa-case (Fig. 7, B) projecting, no instances were noticed of the fly larvae at work upon the immature stages of the Scoliids. How and where the flies lay their eggs (if they are not actually viviparous) is unknown to the writer, but the subject is one worthy of special research. During February, when the writer had about a hundred cocoons of *Elis haemorrhoidalis* under observation at Aguirre, several instances were noted where Bombyliids emerged ten days after the cocoons had been collected in the fields; the inference is that the immature stages of the Bombyliidæ are spent upon or in the Scoliid after it has spun up, and that their life-cycles occupy ten days at least. At present no further data is available to throw light upon this rather obscure subject.

The Bombyliidae are represented in Porto Rico by numerous species, varying from a little less than a half an inch' (the smaller *Anthrax*) to over one and a half inches (the larger (*Hyperalonia*) in the spread of the wings. Not all of them are parasitic upon Scolidae, however, some of them being enemies of the Pompilidae or Spider-wasps (*Pepsis*) and the Sphegidae or Grasshopper-wasps (*Ammobia, Sphex*), etc. In two cases only is the association of a Porto Rican Bombylid with its correct host actually known: (i) *Anthrax gorgon*, F., parasitic on *Elis haemorrhoidalis*; and (ii) *Anthrax lucifer* F., parasitic on *Dielis dorsata;* it is believed that the second instance is a new record for the Island.*

THE TACHINID FLIES

In British Guiana the writer has bred a small species of Tachinid from cocoons of a Scoliid, probably *Tiphia parallela*, Sm., and it is not improbable that in other countries flies of the same family attack similar species of digger-wasps.

Mr. Smyth gives an instance of parasitism of the adult of *Dielis dorsata* in Porto Rico, and states that when found at Santa Rita it contained "a single Dipterous puparium, about 5 mm. long, from which issued, on June 18, 1913, ten small Chalcidids, which have not been determined". It seems probable that the Dipteron referred to was one of the Tachinidae, but Mr. Smyth gives no information upon this point.

The writer trusts he will be forgiven the irrelevancy of reminding his readers how strongly the above instance of tertiary parasitism, or hyperparasitism of the hyperparasite, recalls to one's mind the old tag

"Big fleas have little fleas
Upon their backs to bite 'em;
And little fleas have lesser fleas,
And so *ad infinitum*."

THE RHIPIPHORID BEETLES

A group of insects more or less specialized to a habit of parasitiz-

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* *Anthrax lucifer* is a primary parasite on certain Lepidopterous larvae in the U S. A. In this role the fly is beneficial to man. As a parasite of Scoliids it is noxious H. E. B.

ing the fossorial Hymenoptera, including the Scoliidae, is the family Rhipiphoridae, the members of which are rather small beetles of curious aspect (Fig. 8). The writer found these insects quite commonly in British Guiana upon plants frequented by Scoliids, but has so far not met with them in Porto Rico, although Wolcott lists five monly in Brithis Guiana upon plants frequented by Scoliids, but has here.

It is not known definitely how these beetles succeed in parasitizing their host, for they do not appear to go underground in search of them, spending most of their time upon flowers and such vegetation where the wasps abound. Dr. J. J. Davis suggests that the eggs are probably laid on or near flowers frequented by the wasps, or possibly on the body of the wasp itself, and that the egg or the newly-hatched.

HYPERPARASITES OF SCOLIIDAE

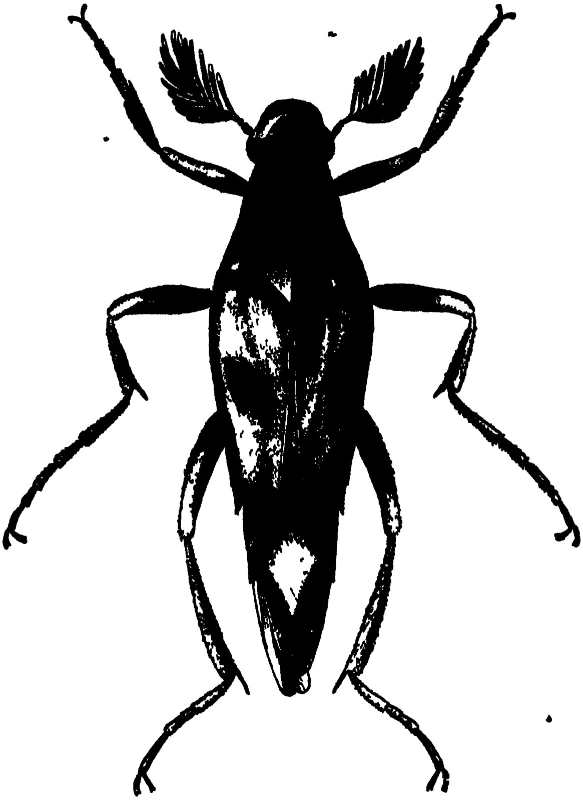

FIG. 8.—Rhipiphoridae

Adult of typical species (8 times natural size) (from Davis)

Rhipiphorid larva becomes attached to the hairy body of the wasp and is in due course transported to the site of the latter's operations upon a white grub, when it becomes detached. This is very probably the true explanation of what happens, for it is known that a similar ingenious method is adopted by a related family of parasitic beetles—the Cantharidae—whose first-instar larvae (called *triungulins*) are very active, and cling to the hairy bodies of certain bees, being carried by the bees to their nests, upon arrival at which they become detached, cast their skins, and losing practically all power of locomotion, settle down to a parasitic existence upon the bee larvae.

It will readily be understood how important is the quarantining of any Scoliids or other fossorial wasps that are introduced as larvae or cocoons from abroad, in order to prevent the escape of such insects as those mentioned above, for not only is there the danger to the species being introduced, but the foreign hyperparasites might, and very probably would, adapt themselves to attacking the indigenous Scoliids as well as other kinds of beneficial wasps, with disastrous results. The method adopted by most workers is to put each individual Scoliid in a separate tube, within which the emergence of the wasp or its parasites takes place, when the former can be transferred to breeding-cages, the latter being destroyed before they can breed.

PARASITIC FUNGI

In addition to the predators and parasites discussed above, there are certain fungi which cause a heavy mortality among Scoliids, especially during the pupal stage of the wasps. These fungi, principally species of *Isaria,* are the cause of great trouble when the wasps are being reared artificially, and at present no sure means are available for preventing such losses; keeping the cocoons in an atmosphere fairly dry, however, is calculated to reduce the mortality to a minimum, although the atmosphere in which they are kept should not be absolutely dry, a certain amount of moisture being necessary for their development. Infection by fungi has greatly handicapped the rearing of Scoliids at Aguirre, but the writer hopes that with proper facilities these difficulties will be overcome. At certain seasons a fairly high percentage of Scoliids succumb to fungal attack under actual field conditions, which subject has been treated more or less at length by writers in other countries; no data are at present available, however, upon the prevalence, if any, of fungi upon Porto Rico Scoliidae under actual field conditions.

ECOLOGY OF THE SCOLIIDAE; IMPORTANCE OF NECTAR-BEARING PLANTS

More than one observation has been made in this paper relative to the importance of having suitable food-plants available for the successful propagation of Scoliid wasps in a state of Nature, and, although at present the writer does not feel competent to offer more than a few cursory remarks upon it, the subject is one worthy of a great deal of close attention and study. The observations that follow are based for the most part upon the writer's experience upon the South of Porto Rico, and hence should not be taken as necessarily applying to the Island as a whole.

The fact that several of the indigenous Scoliids of Porto Rico are common to both the north and the south of the Island suggests that they are fairly adaptable climatologically, and from records in literature, supplemented by observations made by the writer, it appears that they are in a large measure adaptable to the vegetation of the two regions.

ECOLOGY OF SCOLIIDAE

FIG. 9.—Near Santa Isabel, P. R. *Callejón* with thick growth of *Kallstroemia maxima*, a favorite haunt of *Dielis dorsata*, F. (Photo. H. E. Box)

The vegetation of the north of Porto Rico differs considerably from that of the arid regions on the south coast, but both districts possess a variety of plants whose flowers prove attractive to many Hymenoptera, especially the Scoliidae. Where irrigation is practiced (and there are few parts where it is desirable to establish the wasps where irrigation is not practiced) the wild plants approximate more closely to those of the naturally moist regions, but, nevertheless, there is ample room for extending the distribution of such plants as are desirable in order to obtain the maximum benefits from the wasps.*

It often happens that plants which come into flower at certain seasons are, upon the commencement of their fruiting season, not always succeeded by the appearance of other suitable flowers, so that the wasps, in order to obtain the nectar so necessary to them, are forced to temporarily quit these localities and migrate to places where suitable flowers are to be found. It is believed that with proper study this state of affairs can be adjusted, and a succession of nectar-bearing flowers made to appear throughout the year, by planting, or at least encouraging, certain types of insect-fertilized plants; the subject, however, require a much greater amount of study than the writer has so far been able to devote to it.

ECOLOGY OF SCOLIIDAE

FIG. 10.—Near Salinas, P. R. Similar spot to Fig. 9, where both *Dielis dorsata*, F. and *D. trifasciata*, F. occur. (Photo. H. E. Box)

On the south of Porto Rico there are two plants of special interest in this connection. The first of these is *Commicarpus scandens*, Linn. (Stand.), known locally as "*pega-pega*", which is a stick-seeded vine of somewhat dense growth belonging to the order Nyctaginaceae, and occurs in more or less abundance upon the fences bordering plantation roads (Fig. 11). The flowers are quite small, about an eighth of an inch in diameter, pale yellow in color, and are borne upon inflorescences measuring about one inch in diameter; towards dusk their aroma is perceptible. On sunny mornings large numbers of insects are to be seen in the vicinity of these vines, imbibing nectar from the flowers; the majority of the insects will be found to be bees and wasps, and among the latter the Pompilidae and Scoliidae easily predominate, the former being represented by *Pepsis* and *Psammochares*, both of which prey upon spiders, while the Scoliids are represented by *Elis* and *Dielis*.

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* The writer is attempting to propagate artificially a somewhat rare species of *Paullinia*, the flowers of which are very attractive to anthopilous Hymenoptera.

Commicarpus scandens comes into full bloom from January until April and again from late July until November, and during both flowering seasons large numbers of fossorial Hymenoptera can always be observed. Where these wasps go to during the non-flowering season of this plant has not yet been ascertained, but it is believed that the flowering of the plant has an influence upon the abundance of the wasps in any given locality.

ECOLOGY OF SCOLIIDAE

FIG. 11.—Near Coamo, P. R. Roadside fence covered with tangled growth of *Commicarpus sacandens* in full bloom, a favorite haunt of *Elis haemorrhoidalis*, F. (Photo. H. E. Box)

The other plant whose presence in abundance is intimately connected with that of fossorial wasps is *Kallstroemia maxima* (*yerba de cerdo*), a member of the Zygophyllaceae, with pale yellow flowers reminiscent of the buttercups *Ranunculus* of temperate climes, and whose general growth and habitat are suggestive of the common *verdolaga* (*Portulacca oleracea*, Linn.), with which it may easily be confused by the uninitiated. On the south of Porto Rico the *yerba* *de cerdo* occurs in many situations where conditions do not favor the growth of the *verdolaga*, which prefers the *poyal* lands to the sandy spots where the first-named plant abounds. Many of the *callejones* separating canefields at Aguirre are literally carpeted with a thick growth of this weed (Figs 9 & 10), and during its flowering season (which appears to be continuous, with an optimum in July and August) thousands of Hymenoptera are attracted by its delicate perfume; among the wasps the Scoliid *Dielis dorsata* is the most

ECOLOGY OF SCOLIIDAE

FIG. 12 —Guaimati, near La Romana, Dominican Republic. Broad "*carriles*" with undergrowth of grass; principal nectar-bearing flowers are these of *Paullinia pinnata*, growing over young *guacima* trees, favorite haunt of many species of Scoliidae, especially *Dielis atrata*, F. (Photo, H E Box)

frequent and on sunny mornings thousands of the females of this species may be seen in most places where this plant occurs.

Other plants which have been found attractive to Scoliidae in Porto Rico are the white-flowered mint *Hyptis atrorubens* (Labiateae), the common blue verbena, *Stachytarpheta jamaicensis* (Verbenaceae), and *Mitracarpus portoricensis,* recorded by Mr. Wolcott, to which the writer can add the yellow ironweed or *escoba, Sida carpinifolia* (Malvaceae), a purple-flowered mint, *Leonurus sibiricus* (Labiateae), and *Leucaena glauca* and an un-named spiny-stalked *Mimosa* (Leguminosae). The large moca trees (*Andira inermis,* Urb.), when in bloom, are attractive to bees of various genera, but do not seem to be especially so to the wasps, although *Dielis dorsata* has been noted more than once at their blossoms.

Certain Scoliids, *e. g.*, some species of *Tiphia,* are not anthophilous; their females refresh themselves with the honey-dew secreted by aphids and scales, and hence a difficult problem is presented, for to provide a larger amount of scale or aphid-infested vegetation, though beneficial from the view of tending to encourage *Tiphia,* is in all other directions detrimental to the Island's interests. As an alternative, the writer believes that both the indigenous species of *Tiphia* and any that may be introduced in the future, can be assisted in their propagation by importing into the Island certain species of *Cordia* (Boraginaceae), possessing hair-like glands upon the leaves, which secrete a sweet honey-dew very attractive to Scoliids and other wasps. Several species of *Cordia* occur in Porto Rico, but the writer has not observed any of them to possess the faculty of attracting fossorial Hymenoptera during their non-flowering season, such as occurs with *Cordia aubletii* in British Guiana and *C. interrupta* in Barbados.

The seasonal distribution of the Scoliidae, and the factors governing their relative abundance, are subjects of paramount importance, yet which cannot be discussed owing to the short time that the writer has been able to devote to them. Undoubtedly climatic conditions cause fluctuations in the curve of their abundance, and in the time occupied in their early stages underground, as well as in their geographical and topographical distribution. These and other important considerations must be left over to some future publication.

METHODS OF REARING SCOLIIDAE

Provided reasonable care is taken there should be few difficulties attached to the successful rearing of Scoliids either in small numbers or in bulk upon a commercial scale; the chief thing to be observed is the correct regulation of the temperature and humidity of the receptacles used; these should be kept as far as possible at a temperature of a few degrees above or below 80° F., and the soil in them kept slightly moist, but not wet. Frequent changes of the soil are necessary, unless sterilized earth is used. To carry out the work upon anything like a large scale, however, insectaries, equipped with incubating departments, would become necessary. No expense should be spared to make the building where rearing work is being carried on as free as possible from ants, silver-fish, and especially mites. We hope the day will come when the sugar-cane properties of Porto Rico (or at least the larger ones) will be provided with field insectaries for breeding parasites, similar to those in use in the Californian citrus-growing regions, where millions of ladybird-beetles (Coccinellidae) are raised annually to combat the scale-insects that would otherwise ruin thousands of dollars' worth of fruit-trees.

Four operations are concerned in the raising of Scoliid wasps: (i) oviposition; (ii) rearing the larvae to maturity; (iii) care of the cocoons; and (iv) mating. Most of the apparatus is such that can be procured at almost any hardware store, but for certain stages of the work the writer uses special boxes and cages. It must be remembered that we have only recently commenced the work of breeding Scoliids at Aguirre, and that probably as time goes on modifications will be made in the process described below:

I. OVIPOSITION

For the smaller species of *Dielis*, and *Elis*, glass fruit jars (Atlas pattern), 5½ inches high by 3⅜ inches top diameter, are used, while for the large *Dielis atrata* jars of similar diameter, but 9½ inches high, are to be recommended. The glass lids and rubber bands are removed from the tops of the jars, which can be covered with removable standard-size lamp-chimmeys 3½ inches in diameter at the base; these chimneys conveniently rest upon the rims of the jars, and their tops are covered with muslin or other cloth kept tight by means of rubber bands. The jars are loosely filled with sifted (and sterilized, if possible) soil, to within an inch of the top, and into the surface of the soil is stuck a sprig of some flowering plant upon the leaves of which some diluted honey has been sprinkled. The appearance of this apparatus as at present used at Aguirre is shown in Figs. 13 & 14.

The chimney is removed and a suitable living white-grub placed in the soil a few inches below the surface, after which a female wasp is let loose within the chimney, which is rapidly placed over the jar, and the whole ticketed for reference and left for a length of time sufficient for parasitism and oviposition to take place. Generally the wasp drags the grub to the bottom of the jar, where she makes a cell around it, in contact with the side, so that often the grub can be viewed through the glass. When an egg has been deposited, indicated by the wasp coming up into the open air, the soil is gently tilted out of the jar, the wasp having been captured in a small tube, and the paralized grub with the wasp's egg attached removed with forceps, or by means of a long-handled spoon, after which another grub is placed in the soil, the wasp returned, and the chimney replaced, for the process to be repeated. Under properly organized conditions two changes per day may be considered desirable. It often happens that grubs are stung without being oviposited upon by the wasps, when they have to be replaced by fresh living grubs, though in one or two instances the writer has been able to get the wasps to oviposit upon a paralized grub which has been put back into the jar. When such a grub is left on the surface of the soil, the wasps will endeavor to drag it down to the bottom of the jar, often becoming exhausted by so doing; such conditions, being unnatural, are not to be encouraged.

II. REARING THE LARVAE TO MATURITY

For rearing the wasp-larvae the writer has designed a type of box, 15 inches square at the base and 4 inches deep, with hinged lid of the same dimensions, fitting tight by means of flanges. The centre of the lid is cut out for a space 11 inches square to allow of the insertion of copper mosquito wire, thereby providing for aeration. At one side of the lid is a round hole, 2 inches in diameter, which can be closed when necessary, but which, when open, allows the insertion into it of a bottle whose mouth is of a size which enables it to be pushed into the hole more or less tightly (Figs. 13, B & 15). Moulding sand is put into the box to a depth of three inches, and rows of depressions made in the sand while it is still damp, these depressions being of a size suitable for the accommodation of the paralyzed grubs.

When a paralyzed grub with egg attached is located in one of the oviposition jars, it is removed and placed upon its back in one of the depressions in the moulding sand, an indentification number placed immediately above it, and is left until the egg hatches.

FIG. 13.—Apparatus employed in artificially rearing Scoliidae. (Photo. Rodríguez Serra, Ponce)

A—Oviposition jar with lamp chimney

Consumption of the grub by the wasp-larva takes place within the shallow depression, and when the wasp-larva is mature, the depression serves as the base of a cell for the formation of the cocoon; without this small device (which the writer gleaned from Dr. Illingworth's paper on similar work done in Queensland) the larvae are unable to form cocoons and perish.*

III. CARE OF THE COCOONS

In large-scale work the cocoons would be left *in situ* as they are formed, but at present they are being removed to another similar type of box. The sand should be quite dry, and the necessary moisture obtained by covering the lid with a double layer of damp cloth, over which a piece of card-board is laid; in such an atmosphere created within the box, the cocoons do very well. As the pupal stage lasts at least one month, it is necessary to constantly watch out for the apperance of moulds or other fungi; when fungi are found the cocoons should immediately be transferred to another box containing fresh sand.

Wasps as they emerge from the cocoons will readily fly into the glass bottle inserted in the side of the lid of the box, being attracted thereto by the light shining through the aperture, the rest of the box being dark.**

IV. MATING

The wasps are transferred from the glass bottles to small wooden cages, 12 inches high upon a 9 by 9 inches base, containing a bunch of nectar-bearing flowers. Mating takes place within these cages, the females being removed twenty-four hours after being put with the males, of which there should be three or four for every female present.

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* Since the above was written, the writer has found it safer and very much more convenient to place each paralysed grub with its attached egg inside a glass tube, two and a half inches long by half an inch in internal diameter, the ends of which are plugged with absorbent cotton. Growth and pupation of the Scoliid larva takes place within the tube without any risk of contamination from neighboring grubs which may be infected with *Metarrhisium* or other fungi, as well as those plagues of the insectary, the Acarina or Mites. The cocoons when properly hardened on the outside are easily removed from the tubes and transferred to storage boxes.—H. E. B.

** A very heavy mortality occurred among the eggs, larvae, and cocoons of a species of Scoliid being reared at Aguirre during 1925, and this was found to be due in large measure to unsuitable temperature. Incubators were improvised by means of enclosing electric-light bulbs in boxes of suitable dimensions, the interior of which maintained a temperature varying little from 80 degrees F. The smaller boxes containing developing larvae and cocoons were stored in these "incubators" and very much better results were obtained than when they were left exposed to the fluctuations of room temperature, which frequently dropped below 70° F. at night. It cannot be said, however, that we have yet found a really satisfactory method of raising Scoliids during the cooler months of the year, and much research will have to be done before this is likely to be obtained.—H. E. B.

RECORDING DATA

As a basis for all future work it is necessary to keep accurate

TWO VIEWS OF THE TEMPORARY PARASITE LABORATORY, CENTRAL AGUIRRE.

FIG. 14.—Oviposition. Jars. (Photo. H. E. Box)
Right for the medium sized *D trifasciata*
Left: for the large *Dielis atrata*.
Note Mating Cages behind large jars

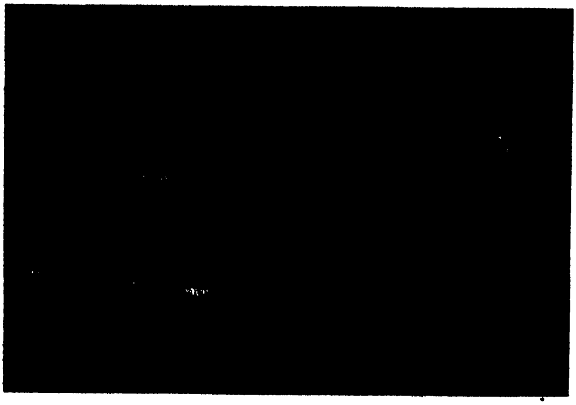

FIG. 15.—Boxes for Rearing the Larvae and Storing the Cocoons. (Photo. H. E. Box)

records of all ovipositions, hatchings, pupations, and emergences. The system adopted is to give the female wasps of each species an identification number consecutively as they are obtained either by being collected in the fields or by having emerged in captivity, the former bearing the prefix "O" (original series), while the latter of the first generation have the prefix "I" those of the second generation "II", and so on. The eggs as they laid are also numbered consecutively, the egg numbers being prefixed by the serial and individual numbers of the parent; by this means the ancestry of any particular individual can be traced, and, on the other hand, it is possible to trace the entire progeny of any female.

THE SPECIES OF PORTO RICAN SCOLIIDAE *

Mr. Wolcott, in his "Insectæ Portoricensis", lists the following species of Scoliidae recorded as occurring in Porto Rico:

1. *Elis haemorrhoidalis, Fabricius* (=*E. sexcincta*, F.)
2. *Elis ephippium*, Fabricius
3. *Elis nitida,* Smith (as *Myzine*)
4. *Tiphia argentipes,* Cresson
5. *Tiphia* sp., probably the same as No. 4
6. *Dielis atrata, Fabricius* (as *Campsomeris* and *Scolia*)
7. *Dielis pyrura,* Rohwer (*as Campsomeris*)
8. *Dielis pyrura,* Rohwer (as *Campsomeris*)
9. *Scolia plumipes,* Drury
10. *Dielis maculata,* Drury (as *Campsomeris*) (=*C. druryii*)
11. *Dielis tricincta,* Fabricius (as *Campsomeris*)
12. *Dielis trifasciata,* Fabricius (as *Campsomeris*)

DESCRIPTION AND DISCUSSION OF THE PORTO RICAN SCOLIIDAE

The following account of the Scoliid wasps of Porto Rico is far from complete, but it is considered advisable to place on permanent record the observations that have been made by the writer to date, as well as to summarize in a convenient form what was previously known of these insects; the records are based whenever possible upon the writer's own observations, but where these are not available free use has been made of Mr. Wolcott's invaluable check-list and other publications. Some of the rarer species have not been met with by the writer in Porto Rico, but were found on the Romana properties in the Dominican Republic; observations based upon this Dominican material of the Porto Rican species are included in this discussion for convenience.

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* The writer is indebted to Mr. G. E. Bryant, who, while temporarily acting as Director of the Imperial Bureau of Entomology, London, England, very kindly supplied information relating to synonymy among the generic names of the Scoliidae, leading to the adoption of the nomenclature employed throughout this paper. It may be worth mentioning that the species referred to as the genus *Dielis* have hitherto been included among *Campsomeris*, which, it is pointed out, is synonymous with *Scolia*, the latter name taking predominance. The species of West Indian "*Campsomeris*" are properly referrable to *Dielis*.

The descriptions are not to be interpreted as being technical diagnoses of the species, but merely as general aids to their identification.

1. *Elis haemorrhoidalis*, Fabricius

(Fig. 16)

DESCRIPTION:

Female—Length 10–12 mm., wing expanse 18–20 mm. Black with several bright yellow marks upon the head and thorax; abdomen with a series of five yellow bands, interrupted dorsally so that there appears to be a black stripe along the back, posterior end of the abdomen red; legs red; wings transparent.

Male—Length 11–14 mm., wing expanse 20–24 mm. Head and thorax with markings somewhat similar to those of the female; abdomen very slender, black with six narrow yellow transverse bands which are *not* interrupted dorsally; posterior end of the abdomen black; legs red; wings transparent

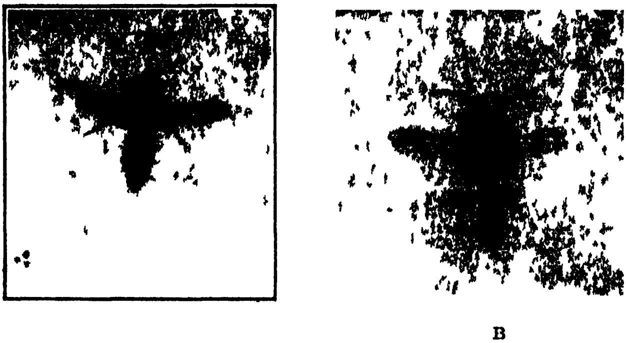

FIG. 16.—*Elis hemorrhoidalis*, F. (natural size)
(Photo H L Dozier)
A—Female B—Male

HOSTS: *Phytalus apicalis*, Blanch (third-instar larvae)
HYPERPARASITE: *Anthrax gorgon*, F. (Bombyliidae).
DISTRIBUTION: Fairly common all over Porto Rico, but inclined to be locally abundant; not known from elsewhere.
FOOD PLANT OF FEMALE: *Commicarpus scandens* ("*pega-pega*")

On the south coast this species occurs abundantly in certain restricted localities, in one of which parasitism was found to amount to 65 per cent of all *Phytalus* grubs during February and March. The males could be seen in hundreds flying over the surface of the ground or resting in clusters upon the leaves and flowering spikes of *bledo* (*Amaranthus* sp.) in the vicinity, while large numbers of the females occurred during the mornings on their food-plant, *Com-*

PLATE III

FIG. 17.—*Elis ephippium*, F. (natural size)

Female at left, male at right
(Del. ad. nat. H. E Box)

micarpus scandens. Advantage was taken of the abundance of the females of this wasp to collect and transport them to another *hacienda* some thirteen miles eastward, where *Phytalus* grubs were known to be common in certain fields, but where hitherto no signs of the presence of the parasite has been noticed. During February and March 1,200 females were collected and released in the new locality, with the result that on the 3rd of April they had accounted for 7 per cent of the *Phytalus* grubs, while three weeks later parasitism had amounted to 26 per cent. During late May and early in June the parasities were more abundant in their new quarters than in the locality from which they had been taken. At the time of writing (August), owing to the absence of *Phytalus* grubs in numbers, *E. haemorrhoidalis* is comparatively scarce in both regions, nevertheless sufficient has been accomplished to demonstrate the possible results obtainable by transporting parasites from places where they abound to parts where they are scarce or absent. It is planned to make further distributions of *E. haemorrhoidalis* when next it can be found in sufficient numbers to enable collections to be made. The males, it may be of interest to record, are very fond of flying around, and resting upon, the white flowers of the Composite weed *Parthenium hysterophorus*, L., a plant which does not appear to be attractive to the females.

The complete life-cycle was worked out in one instance only, and consequently should not be regarded as typical, as it may not represent the average:

TABLE I

LIFE-CYCLE OF *ELIS HAEMORRHOIDALIS*, F.

Egg No	Egg Laid	Egg Hatched	Egg Stage	Larva Spun up	Larva Stage	Adult Emerged		Cocoon Stage	Total, egg to adult.
	Date	Date	Days	Date	Days	Date	Sex	Days	Days
1/1	16 iii	17 iii	1 5	21 iii	4 5	30.iv	m	41	47

2. *Elis ephippium*, Fabricius

(Colored Plate III, Figure 17)

DESCRIPTION:

Female—Length 15–25 mm., wing expanse 20–30 mm. Entire body black except for the centre of the dorsal part of the thorax, midway between the bases of the wings, where there is a rectangular spot bright red in colour; legs black, wings transparent, slightly smoky towards apex.

Male—Length 18–22 mm., wing expanse 28–34 mm. Very similar to the male of *E. haemorrhoidalis*, but larger. Head and thorax with a number of transverse yellow bands, and a pair of short longitudinal bars, on penultimate segments; legs dark yellow; wings transparent yellowish.

HOST: Unknown in Porto Rico.

HYPERPARASITES: Unknown.

DISTRIBUTION: Porto Rico, St Thomas, Antigua. Stated by Wolcott to be rather common during the fall on the north of Porto Rico, around the Río Piedras district.

FOOD-PLANT OF FEMALE: Smyth states that the females occur on the flowers of *Hyptis atrorubens*.

This is one of the Scoliids whose distribution in Porto Rico, so far as is at present known, is confined to the north of the Island, and is one which the writer considers should be bred and tried out upon the south coast. Although a fairly large number of females have been obtained from time to time by the entomologists of the Experiment Stations, nothing appears to be known of the host of this parasite in Porto Rico.

Owing to the fact that *Elis xanthonotus*, Roh., a species so closely resembling *ephippium*, F. as to appear identical except to an expert, attacks and can be reared upon the second-instar larva of *Lachnosterna portoricensis*, there is every reason to believe this beetle to be the host of *ephippium* in Porto Rico.

In Santo Domingo the writer collected two female *Elis* of the same general *facies, i. e.,* black with a red mesonotum * on flowers of *Paullinia pinnata*. Both of those insects arrived alive at Aguirre, and one of them oviposited six times upon *L. portoricensis* grubs; the mortality was heavy and only one specimen, a male, was raised from this material. Believing the female to be the same as the Porto Rican *ephippium*, the writer was astonished to find the male quite different from specimens of *ephippium* collected at Río Piedras. The other female from Santo Domingo did not oviposit, though it stung *portoricensis* grubs in the rearing-jars.

The three individuals, a female and its male progeny, and another female (which differed visibly from the first, particularly in the shape of the colored thoracic area and in the presence of a yellow bar posterior to it), were forwarded to Dr. L. O. Howard, who kindly gave them into the hands of Mr. S. A. Rohwer of the United States

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* In Mr. Rohwer's original description he states that *xanthonotus* is "Readily distinguishable by its black color and yellow mesoscutum". The mesoscutum in the example collected in Santo Domingo is bright red, a color to which the yellow parts of Hymenoptera frequently change when the specimens are left in cyanide-bottles for any length of time, so it is possible Mr. Rohwer was misled into believing the red color of the mesoscutum in preserved specimens was yellow in life.

National Museum. Mr. Rohwer, in his report, separates the species as follows:

The female with bred male is stated to agree with the type of *xanthonotus,* Roh., which was described in 1915 from one female collected at Río Piedras, Porto Rico, by Mr. T. H. Jones in 1912. This name was later (1920) sunk by Mr. Rohwer as synonymic with *ephippium,* F. Mr. Rhower states in his report that "The synonymy may be correct but inasmuch as there are two species which agree with Fabricius' original description it seems advisable to use the name *xanthonotus* for this form until the type of *ephippium* can be studied." If by any chance this species is found to be identical with the true *ephippium,* a new name will have to be found for the Porto Rican insect whose male is so very distinct, and which is at present known as *ephippium.*

The solitary female from Santo Domingo "differs from *xanthonotus* in the sculpture of the head and pronotum, etc. It may be *ephippium,* but the type must be examined before it can be determined." The writer finds it to differ from females labelled "*Elis ephippium,* F." in the collection of the Insular Experiment Station of Porto Rico.

It seems, therefore, that *Elis xanthonotus* occurs in both Porto Rico and Santo Domingo, and that in each of these countries there exists one other similar species, neither of which do we believe to be common to both islands.

TABLE II

LIFE-CYCLE OF *ELIS XANTHONOTUS,* Roh.

Egg No	Egg Laid	Egg Hatched	Egg Stage	Larva Spun up	Larva Stage	Adult Emerged		Cocoon Stage	Total, egg to adult
	Date	Date	Days	Date	Days	Date	Sex	Days	Days
1/1	22 vii	24 vii	2	30 vii	6	5 ix	m	37	45

NOTE: This individual was the progeny of a female collected at Guaimati, Dominican Republic, and was reared at Aguirre, Porto Rico, on a 2nd-instar grub of *Lachnosterna portoricensis.*

3. *Elis nitida,* Smith

Unknown to the writer.

A species recorded by Dr. Agustín Stahl in his "Fauna de Puerto Rico" in 1882, which has not been recorded since that date.

This species is also reported from Santo Domingo, Cuba, and Jamaica. Mr. Wolcott informs the writer of recent captures of this species in the vicinity of Port-au-Prince, Haiti.

4. *Tiphia argentipes,* Cresson

Unknown to the writer.

Recorded by H. Dewitz (1881), Dr. Stahl (1882), Dr. J. Gundlach (1894), and Dr. W. H. Ashmead (1900)

Mr. Alex Wetmore records finding *Tiphia* sp. (according to Mr. Wolcott, probably the species under discussion) among the stomach contents of a kingbird, or *"pitirre"* (*Tyranus dominicensis dominicensis,* Gmel.).

T. argentipes is also reported from Cuba and St. Vincent.

5. *Tiphia* sp.

Three males of a *Tiphia,* which, according to Mr. S. A. Rohwer may represent a new species, were found in the Guánica district by Mr. E. H. Barrow in 1921, feeding upon the secretions of a scale, *Pulvinaria psidii,* Mask. on *Rauwolfia nitida.* Another male was subsequently found on cotton at Yauco. At one time it was suspected (on very good evidence, too) that these *Tiphia* might be the progeny of some insects of the same genus brought into Porto Rico during 1913, releases of which were made in the Guánica district.

In Santo Domingo the writer collected two specimens of *Tiphia,* one, a female, on aphid-infested corn in the grounds of the Experiment Station at Santiago, while a male was taken under precisely similar circumstances at La Vega; both of these localities are in the interior of the Island.

The two specimens were examined by Mr. Rohwer, who states the female to be *T. punctata,* Robt., a species known from continental North America ranging from southern Canada to Texas and Louisiana. It has not previously been recorded from the West Indies, so far as the writer knows.

The male from La Vega is stated by Mr. Rohwer to be "the same as has been previously collected by Barrow."

Although there is some evidence that both the male and female *Tiphia* from Santo Domingo are *T. punctata* (in which case the Guánica individuals would also be of this species), there is actually no proof that this is the case, as it was not possible to specifically determine the male sent by the writer to Mr. Rohwer. Definite information can only be obtained by having males bred from known females available for determination.

If Mr. Barrow's specimens are (as the writer believes them to be) of the widely distributed *T. punctata,* it is not improbable that they are descendants of individuals released in the Guánica region by Mr. Wolcott in 1913–14, for *punctata* was included among the introductions to Porto Rico from the State of Illinois. On the other hand, seeing that *punctata* occurs in Santo Domingo, where it was certainly not introduced, there is no reason why the Guánica *Tiphia* may not have been native to Porto Rico.

6. *Dielis atrata,* Fabricius

(Fig. 18)

DESCRIPTION:

Female—Length 35–50 mm., wing expanse 50–75 mm. Head, body, and legs, entirely black; wings dark orange-yellow at the base and for more than two-thirds of their length; apex of the wings smoky by transmitted light, bright steely blue by reflected light.

Male—Length 28–35 mm., wing expanse 40–45 mm. Color the same as that of the female, except that the orange color of the wings is not so pronounced, and the apices of the wings not quite so dark.

HOST: Not definitely proven in Porto Rico, but undoubtedly the larvae of *Stataegus* titanus and *S. quadrifoveatus.* The former species was readily parasitized in the third instar by *D. atrata* brought in from Santo Domingo.

HYPERPARASITES: Unknown.

DISTRIBUTION: Porto Rico, Santo Domingo, Cuba, Jamaica. Stated by Dr. Gundlach (1894) to be very common in Porto Rico, but, nevertheless, during the last two decades and a quarter only two captures have been made*: a male in a canefield at Aguirre (1913, G. N. Wolcott,) and a female at Lares (1923, F. Seín). The writer found *D. atrata* commonly in some districts of the Romana properties, but it was not seen elsewhere in Santo Domingo. Mr. Wolcott informs the writer that it occurs to some extent in Haiti.

FOOD-PLANTS OF THE FEMALE: In Santo Domingo the wasps of both sexes are attracted to the flowers of *Paullinia pinnata.*

Dielis atrata (also referred to as *Scolia* or *Campsomeris atrata*) is one of the largest of the West Indian Hymenoptera, some of the females having a wing-spread of over three inches. Owing to its

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* Since the above was written, the writer has taken two males and two females of *D. atrata* on flowers of *Commicarpus scandens* in one of the Aguirre *haciendas* north of Santa Isabel. The females readily oviposited upon mature grubs of *Strataegus titanus* collected from cane-stools in the same locality

PLATE IV—PORTO RICAN SCOLIIDAE

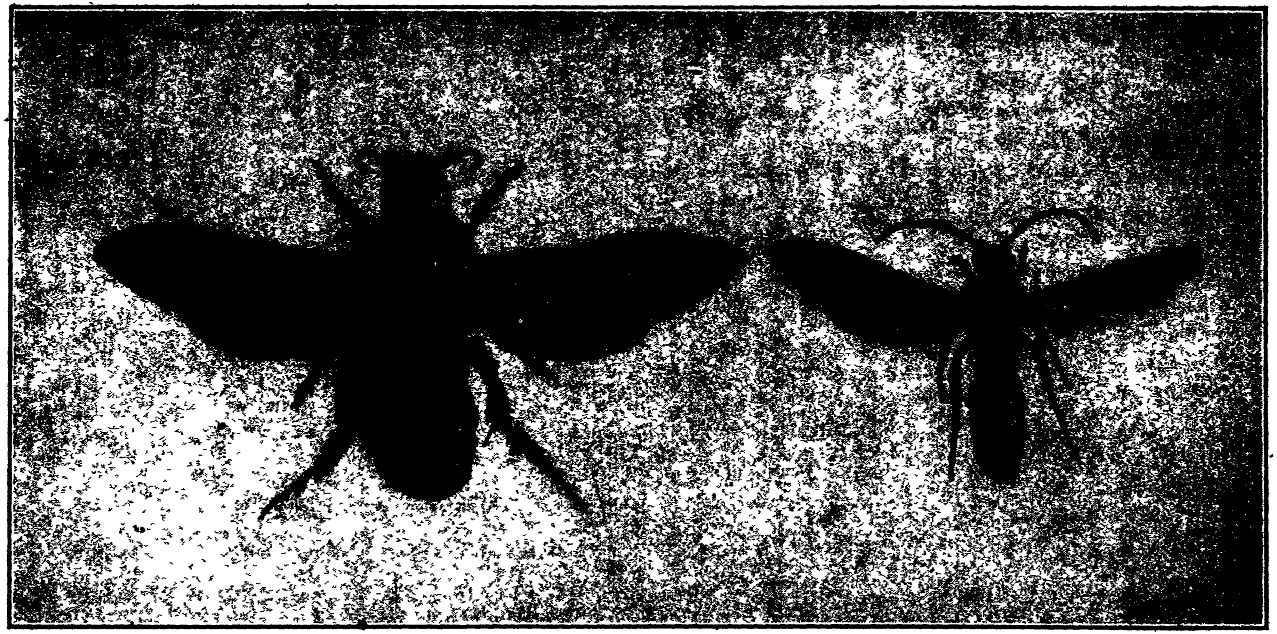

FIG. 18.—*Deilis atrata*, **F. (natural size)** (Photo. Rodríguez Serra, Ponce)
Female at left, male at right

NOTE: The abdomen of the female is considerably longer than appears from the photograph; the example illustrated here has the apical abdominal segments bent downwards, and out of sight.

extreme rarity in Porto Rico during recent years, very little is known of the habits of this species. While in the Dominican Republic in July the writer found *D. atrata* quite common in certain localities near Central Romana in the province of Seiba, and twelve females were collected for shipment to Porto Rico. Only three arrived at Aguirre alive, and these were immediately transferred to jars of soil containing proper food and prey, it being considered that the third-instar grubs of the sugar-cane rhinoceros beetle (*Strataegus titanus*) would serve for the purpose. The wasps commenced to oviposit at once, and eggs were secured from the three individuals, as follows:

Female No. 0-1____23 eggs, between 19-vii and 10-viii (wasp died 10-viii)
Female No. 0-2____12 eggs, between 21-vii and 3-viii (wasp died 5-viii)
Female No. 0-3____23 eggs, between 21-vii and 16-viii (wasp died 18-viii)

Mortality during the egg and larva stages was very high, due to unfavorable conditions, but thirteen cocoons have been obtained, and, provided the sexes are about even, we expect to be able to continue the rearing work upon the emergence of the adults late in September.* Nevertheless, it is proposed to make further importations of *Dielis atrata* from Santo Domingo at some time in the near future, as the species may be reckoned as being very desirable to firmly re-establish upon cane lands in Porto Rico, where, as has already been mentioned, considerable damage is done by rhinoceros beetles and their grubs.

Typical haunts of the adults of this wasp in Santo Domingo are shown in Fig. 12, consisting of broad *carriles* (equivalent to our *callejones*) with a thick undergrowth of grass and weeds interspersed with small *guácima* trees, over which can be found climbing the vine *Paullinia pinnata*, whose flowers are so attractive to the adults The males cluster together upon the leaves and branches of the *guácimas*.

TABLE III

PARTIAL LIFE-CYCLE OF *DIELIS ATRATA*, F.
(Average of twelve specimens)

Egg Stage	Larva Stage
Days	Days
3.5	9.5

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* No adults emerged, as all the pupae became infected with *Isaria* fungus.—H. E. B.

7. *Dielis dorsata*, Fabricius

(Fig. 19)

Description:

Female—Length 20–25 mm., wing expanse 28–35 mm. Head and body black; abdomen with brick-red bars on the second and third segments, each bar of characteristic pattern (Fig. 19, A) legs black; wings almost opaque smocky by transmitted light, bright steely-blue by reflected light.

Male—Length 18–22 mm., wing expanse 25–32 mm. Differs entirely from the female, the species being sexually dimorphic. Body black, covered with a fine greyish pubescense, which appears almost silvery in newly-emerged individuals. There are two curved bars, pale yellow in color, upon the clypeus or face, between the eyes, enclosing a black area; a narrow yellow ring in front of the thorax, just behind the head, and a pair of thickish yellow bars at the base of the thorax, the anterior one being the larger. The abdomen is black, with pale yellow rings upon the first four segments, the rings of characteristic pattern; legs mostly black, but with pale yellow stripes on the inside of each segment; wings transparent with black neuration.

PORTO RICAN SCOLIIDAE

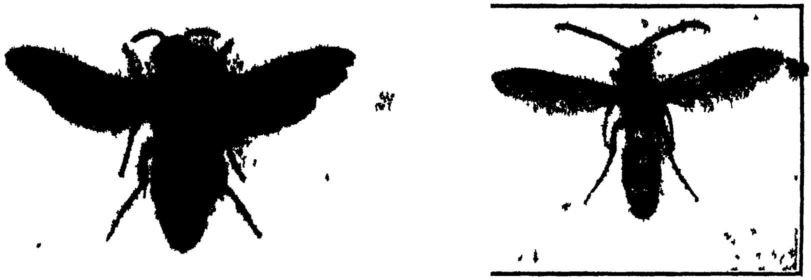

FIG. 19.—*Dielis dorsata* F. (1¼ times natural size) (Photo, H. L. Dozier)
A—Female B—Male

Host: *Ligyrus tumulosus* (third-instar larvae); occasionally the third-instar larvae of *Lachnosterna portoricensis*, and probably *L. vandinei*.

Hyperparasites: *Anthrax lucifer*, F. (Bombyllidae), and an undetermined Dipteron (recorded by Mr. Smyth).

Distribution: South America (Brazil, Guiana, etc.), Barbados, and Porto Rico; was not seen in Santo Domingo. In Porto Rico *D. dorsata* has a wide distribution, but would seem to be more abundant on the south coast.

Food-plants of Female: Almost any nectar-bearing flowers, but especially *Kallstroemia maxima*, *Commicarpus scandens*, *Sida*

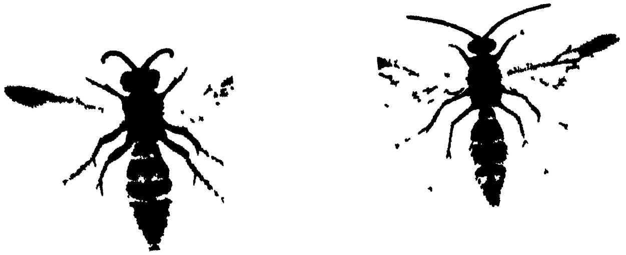

FIG. 20.—*Dielis pyrura*, **Roh.** (1¼ times nat. size)

Female at left, male at right
(Del. ad. nat. H. E. Box)

carpinifolia, and *Leonurus sibiricus*. Occasionally females are attracted to the flowers of the *moca* (*Andira inermis*), as well as those of *Leucaena glauca*.

Dielis dorsata is one of the commonest wasps, and certainly the commonest Scoliid, in Porto Rico, ocurring almost ubiquitously wherever its host abound. When stable manure containing grubs of *Ligyrus* is applied to canefields, *D. dorsata* can shortly afterwards be seen in hundreds in the vicinity of such fields, retaining its abundance until the last of the grubs has pupated or been parasitized. An instance of the effectiveness of this parasite was observed by the writer on the south coast, where, in a *callejón* between two fields of young cane, *Ligyrus* grubs could be collected in thousands during February, while six weeks later it was difficult to find even one specimen, even in the pupal stage, their place having been taken by the enormous numbers of *Dielis dorsata* later present in the locality.

Occasionally cases of parasitism of *Lachnosterna* by this Scoliid are observed in the canefields, and under artificial conditions *D. dorsata* will readily attack *L. portoricencis* when deprived of its normal host. It is recorded by Mr. Wm. Nowell that in Barbados this wasp acts in a similar way, now and again attacking the Melolonthid *Phytalus smithi* as well as regularly parasitizing the Dynastid *Ligyrus*. In British Guiana *Dielis dorsata* is less common than in either Porto Rico or Barbados, but nevertheless it effects an influence upon the abundance of probably both *Ligyrus ebenus* and *L. gyas* in that country.

It is not improbable, in view of the evidence available, that *D. dorsata* is an accidental introduction to Porto Rico, and in any case should serve to exemplify what can be accomplished with a Scoliid parasite upon white brug control. It is suggested that *D. dorsata* might well be tried out in the United States, where it is believed that it does not occur, as it might prove an efficient parasite for *Ligyrus rugiceps*, Lec., a beetle that is sometimes responsible for damage to growing canes in Louisiana.

TABLE IV

LIFE-CYCLE OF *DIELIS DORSATA*, F.

Egg No.	Egg Laid	Egg Hatched	Egg Stage	Larva Spun up	Larva Stage	Adult Emerged		Cocoon Stage	Total, egg to adult
	Date	Date	Days	Date	Days	Date	Sex	Days	Days
2/2	25.vii	27.vii	2	1.viii	5.5	1.ix	m	31	38.5
2/3	26.vii	28.vii	2	2.viii	5.5	2.ix	m	31	38.5

8. *Dielis pyrura*, Rohwer

(Color Plate V, Fig. 20)

DESCRIPTION:

Female—Length 22–28 mm., wing expanse 32–40 mm. A very beautiful wasp with the head, thorax, and the end of the abdomen covered with red pubescence; abdomen with brilliant lemon-yellow wavy bands on the first three segments, these bands separated from each other by black patches; legs red, with red spines and pubescence; wings hyaline with red neuration; there is a smoky patch in the region of the apex of the forewing, between which and the base, on the costal region, is a broad orange-colored streak, which blends into the pale yellow of the rest of the wing; the apex of the wing reflects a violet color.

Male—Length 18–22 mm., wing expanse 28–35mm. Colored very similar to the female, but there are yellow bands upon the front of the face, situated obliquely between the eyes, enclosing a black space; the thoracic marks are similar to those of *D. dorsata*, but of a deeper yellow.

HOST: Unknown in Porto Rico. A female brought in from Santo Domingo has been found to parasitize the third-instar grubs of *Lachnosterna portoricensis.*

HYPERPARASITES: Unknown in Porto Rico, but probably the same as those of *D. dorsata.*

DISTRIBUTION: Porto Rico, Santo Domingo and Haiti. In Porto Rico the species is decidedly rare; individual specimens have been taken at Mayagüez (type material of the species), Comerío, and Mona Island. In Santo Domingo the writer found a few specimens at Guaimati. Mr. Wolcott states that it occurs sparsely near Port-au-Prince, Haiti.

FOOD-PLANTS OF FEMALE: Wolcott states that the female occurs on the flowers of *Stachytarpheta* (*Valerianoides*) *jamaicensis.* In Santo Domingo they were found on *Paullinia pinnata.*

The species now under discussion has not been met with by the writer in Porto Rico, but the opportunity was taken of bringing back two females from Santo Domingo. One of these died shortly after its arrival at Aguirre, but the remaining specimen lived forty days in captivity, during which time twelve eggs were deposited upon third-instar larvae of *Lachnosterna portoricensis;* to date only two cocoons have been secured, mortality among the eggs and larvae having been high.

Dielis pyrura should be obtained in quantities from Santo Domingo and artificially reared until its numbers are sufficiently large to enable field releases to be made in Porto Rican canefields.

TABLE V

LIFE-CYCLE OF *DIELIS PYRURA*, Roh.

Egg No.	Egg Laid	Egg Hatched	Egg Stage	Larva Spun up	Larva Stage	Adult Emerged		Cocoon Stage	Total, egg to adult
	Date	Date	Days	Date	Days	Date	Sex	Days	Days
1/1	24.vii	28.vii	8.5	5.viii	8	...		....	*.. ....
1/4	11.viii	15.vii	4	22.viii	7	29.ix	f	38	49

* Failed to finish pupation

9. *Scolia plumipes*, Drury

Unknown to the writer.

Recorded by H. Dewitz (1881) and Dr. Gundlach (1894); stated by the latter entomologist to be rare.

10. *Dielis maculata*, Drury

Unknown to the writer.

Recorded by Dr. Ashmead (1900).

11. *Dielis tricinta*, Fabricius

Unknown to the writer.

Recorded by Dr. Stahl (1882), Dr. Gundlach (1894), and Dr. Ashmead (1900). This species is also reported from Santo Domingo, Cuba, Jamaica and Trinidad.

12. *Dielis trifasciata*, Fabricius

(Fig. 21)

DESCRIPTION:

Female—Length 22–25 mm., wing expanse 30–38 mm. Head and body black, with brilliant lemon-yellow bands on first three abdominal segments, these bands separated from each other by black bands bordered with a red line anteriorly where the black and yellow meet; legs black; wings yellowish by transmitted light, with a smoky patch at apex of fore-wings, reflecting purplish; neuration reddish.

Male—Length 18–25 mm., wing expanse 25–32 mm. Body black, covered with dark grayish pubescence. There is a strong similarity between the male of this species and that of *D. dorsata*, but the clypeus is entire yellow, and the abdominal rings are different in shape; the last ring is interrupted dorsally. The yellow markings are darker in tint than those of the male *D. dorsata*, and the wing neuration is reddish rather than black.

HOST: Hitherto unknown in Porto Rico. The writer has found that this wasp normally attacks *Lachnosterna portoricensis*, and in all probability *L. vandinei* is also parasitized by it.

Hyperparasites: Unknown in Porto Rico, but probably the same as those of *D. dorsata.*

Distribution: Porto Rico, Santo Domingo, Haiti, Cuba and Jamaica. Stated to be not uncommon on the north of Porto Rico, but until recently has not been met with on the south coast; where it has now been found in one restricted locality near Salinas. A few individuals were seen at Guaimati in Santo Domingo. Mr. Wolcott says it is "common" in Haiti.

Foodplant of Females In Porto Rico, *Kallstroemia maxima* and *Sida carpinifolia.* In Santo Domingo, *Paullinia pinnata.*

On the 6th of June, while watching thousands of the females of the common *Dielis dorsata* flying around patches of *yerba de cerdo* (*K. maxima*) in a *callejón* in one of the Aguirre *haciendas* the writer collected a few individuals which later were identified as the species now under discussion. Search was continued and visits made subsequently and to date eighteen of these wasps have been secured from the one locality. Although similar places elsewhere have been carefully watched, *D. trifasciata* has not been met with outside an area of less than five acres. It may be worth mentioning that, although four was the maximum number of females of *D. trifasciata* collected on any one occasion, several thousand of the common *D. dorsata* could have been netted had they been required.

PORTO RICAN SCOLIIDAE

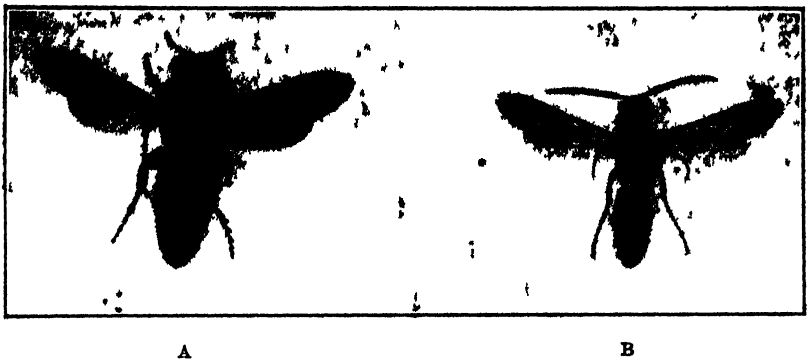

FIG. 21.—*Dielis trifasciata,* F. (1¼ times natural size) (Photo, H. L. Dozier)
A—Female B—Male

The female wasps were collected alive and brought to the laboratory, where they were put into jars with an assortment of white grubs of different stages of *Lachnosterna* and *Ligyrus,* as well as some small *Strataegus.* The two latter types of grubs were absolutely ignored, nor has the writer since been able to get *D. trifasciata* to parasitize either *Ligyrus* or *Strataegus*. The females, however, readily stung the mature third-instar grubs of *Lachnosterna portoricensis*, and laid eggs upon them, thereby constituting the first known instance of parasitism of a Porto Rican *Lachnosterna* by a native Scoliid wasp.

At first the best results were not obtained, the wasps dying after having laid a few eggs, but, with the improved technique already detailed, the wasps were kept alive for a considerable length of time, depositing eggs upon cane-grubs daily. From the original material four generations have been reared upon cane-grubs, but owing to a series of accidents, the work of rearing this species has not progressed as well as we would have desired. To the end of 1925, that is, within a period of six months, 304 individuals (213 males, 91 females) have been raised from the original fourteen specimens, the latest examples being the third filial generation. The maximum number of eggs obtained from one female was fifty-five (this individual lived 63 days in captivity), the average number being 17 eggs for every female wasp. Some females produced all male progeny, and it was thought that this was due to these having developed parthenogenically; to confirm this, two females, kept away from males, laid eggs which almost invariable produced males, though in two instances female progeny were obtained from unfertilized parents; the female progeny were quite healthy and oviposited normally whether they had been fertilized by males or not. Having had such a large number of these Scoliids on hand for a fairly long period, the writer can record data based upon observations on the effect of temperature on their development:

TABLE VI

LIFE-CYCLE OF *DIELIS TRIFASCIATA*, F.

Period	Temperature			Egg Stage	Larva Stage	Pupa Stage	Total, egg to adult
	Daily Mean	Max.	Min.	Days	Days	Days	Days
June–July	80.60	89	70	2.5	6.5	35	44
August–September	81.28	89	72	2.5	6.5	33	42
November	78.80	86	67	3.0	7.0	42	52

The mortality in all stages increased as the nights grew cooler, so that in order to save the race from dying in captivity artificial heating to be resorted to (see foot-note on page 83). In addition large numbers of eggs and larvae died through attacks of fungi and bacteria. A release of twelve females, all proven to be in egg-laying condition, was made in one *hacienda* in December, in a situation favorable for their establishment. The number is small, but it may be that they will continue to breed, as cane-grubs were plentiful in the fields around the part where the releases were made.

All the evidence points to *D. trifasciata* holding the status exemplified in Diagram B of Plate I, but the writer believes there should be little difficulty in producing the effect illustrated in Diagram C, if every facility is provided to aid this end.

One great difficulty which may be encountered in breeding *Dielis trifasciata* and the other Scoliids is that of obtaining a supply of the right sort of grubs during the season of the minimum abundance of the latter in the fields; this season is June and July in the case of third-instar *Lachnosterna* (see Plate III). Although with diligent search a fair number of suitable grubs can be obtained, it is not wise to rely on this method where large numbers of grubs are daily used in propagating the wasps. It seems that if during the end of April and during May, several thousand of grubs are collected, these can be stored at low temperatures (about 45° F. being suggested) either in a proper cooling plant or a good ice-chest, under which conditions the growth of the grubs is suspended until they are restored to normal temperatures a few days before being required for use.

INTRODUCING PARASITES FROM ABROAD

This is not a new idea in Porto Rico, and a most excellent summary of all that has been done in the direction of attempting the control of the sugar-cane pests of Porto Rico by means of introduced parasites was written by Mr. Wolcott and published in this Journal in January, 1922. Nevertheless, it is felt that the present paper would be incomplete without a brief *resumé* of what was accomplished along these lines.

Although great success followed the importation of the Australian lady-bird beetle (*Cryptolaemus montrouzieri*, Muls.) from North America, to combat scale-insects and mealy-bugs (Coccidae) in Porto Rico, the beetles having become firmly established and widely distributed in the Island, the same cannot be said of the introductions that were made of Scoliid wasps from the United States, due, in the writer's opinion, to an injudicious selection of the country whence the parasites were obtained.

During the period 1911 to 1913 Mr. C. E. Hood, and later, Mr.

Wolcott, was engaged by the Experiment Station at Río Piedras to arrange for the collection of large numbers of *Tiphia inornata,* Say, *T. punctata,* Robt., and other species of the same genus that exert a marked control over *Lachnosterna* in Illinois and other States. The material was collected in the form of cocoons and shipped to Porto Rico, some in cold storage, other at normal temperatures by first-class mail. At first very few adults were secured, but later, when improvements had been made in the methods of handling the insects during transit and after arrival in Porto Rico, good percentages of emergence were obtained. The wasps were tried out upon various white-grubs and although in one or two instances they stung the grubs and oviposited upon them, no cases were recorded where one of the imported species of wasp had been reared to maturity upon a Porto Rican grub. In addition to attempting to rear the wasps artificially upon cane-grubs in captivity, several hundreds of adult *Tiphia* were released in some grub-infested fields on the south coast. It cannot be said definitely that these wasps have entirely failed to become established in Porto Rico, but it is certain that they have not increased to such an extent as to make their presence felt today.

While it is quite possible success might follow introductions of white-grub parasites from North America, the writer considers it far more probable that such would be obtained with parasites from neighbouring West Indian islands and from the mainland of South America, where the necessary conditions approach closer to those of porto Rico, and it seems likely that parasites from these countries stand a better chance of becoming acclimatized in Porto Rico than species native to temperate regions, though this does not necessarily apply to all parasites.

Through the enterprise and interest of the Central Aguirre Sugar Company the writer has already been able to demonstrate that there occur in Santo Domingo several Scoliids (*Dielis atrata, D. pyrura* and *Elis xanthonotus*) which are so rare in Porto Rico that their re-establishment and distribution in this Island is desirable. In addition to these, other parasites were found in Santo Domingo during the writer's short visit in July, in numbers insufficient to make shipments. It is very probable that a more extended survey of other parts of Santo Domingo as well as of those localities already visited by the writer in that country, would reveal the existence of other forms of parasites likely to prove beneficial to Porto Rico, as well as a greater abundance of those already found there in small numbers.

A glance at Appendix II at the end of this paper will serve to show what a field remains in this line of work; the writer considers that Cuba, Jamaica, Trinidad and British Guiana are especially worthy of attention in respect of the species of Scoliids *known* to occur there, and there can be little doubt that an entomologist searching for these insects would find forms not yet described and catalogued. In addition to the countries mentioned above, there are others of the West Indian islands which should be taken into consideration, as well as Columbia and Venezuela on the mainland of South America.

Mention has already been made of *Tiphia parallela*, Sm., which aids in keeping down the numbers of the Melolonthid *Phytalus smithi* Arrow, in Barbados. This Scoliid has a variety of hosts, although in Barbados no Lamellicorn other than *P. smithi* is known to be attacked by it. In Antigua it attacks *Lachnosterna antiguae*, Arrow, a species almost identical in size both in the adult and larval state with *P. smithi* of Barbados, and *L. guanicana* and *L. citri* of Porto Rico. In British Guiana *Tiphia parallela* is not known to attack Melolonthids, but the writer has found cases of parasitism of Dynastids of the genus *Dyscinetus* by it in that country.

In reference to an attempt that was made to introduce *T. parallela* into Porto Rico, Mr. Wolcott states:

> "One hundred cocoons were sent (from Barbados) in April, 1913, arriving a month later, but only ten adults emerged. No special arrangements had been made for attempting to have these breed on the grubs of *Phytalus insularis*, Smyth (*apicalis*, Blanch.), the most nearly related (?) Porto Rican species of grub, and the females did not oviposit on the larger *Lachnosterna* grubs.*"

In spite of the negative results recorded by Mr. Wolcott, the writer thinks that *Tiphia parallela* should be given another trial upon Porto Rican white-grubs, especially those of *Lachnosterna*

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* I consider both *Lachnosterna guanicana* and *L. citri* to be closer relatives of the Barbadian *L* (*Phytalus*) *smithi* than *L.* (*P.*) *apicalis* in spite of the fact that the adults of the two latter species have certain minor features in common that some writers rank as generic differences. As it is the larval stage of these beetles that is selected by the Scoliid parasite as food for its progeny, I fail to see that it matters very much that the presence or absence of a certain detail in the structure of the adult form (in this instance a cleft claw in the male sex) exists, for such must be unknown to the wasp, which is familiar only with the subterranean larva, and which cannot have any idea of what the ultimate development of the larva would be if it left it unstung. There are, to my knowledge, no characters present in the larvae of the so-called *Phytalus* which separate that genus from *Lachnosterna*.—H. E. B.

(See second footnote on page 51.)

guanicana and *L. citri*, and suggests that the introduction be made from British Guiana rather than from Brabados, as they can reach this Island in less than ten days by monthly sailings of the Dutch Royal Mail boats from Georgetown, Demerara, which connect with the "Red D" line at La Guayra, Venezuela. Advantage could then be taken of bringing in several other desirable parasites which occur in British Guiana but not in Barbados, viz., certain Braconidae which prey upon moth borers (*Diatraea saccharalis*, F.).

It may be of interest to record that in the summer of 1924 a consignment of adult females of *Scolia manilae*, Ashm. were brought into Porto Rico from Hawaii, by Mr. Norman Kay, of the Central Aguirre Sugar Company. They had been introduced into Hawaii some years previously from the Philippine Islands to combat *Anomala orientalis*, a sugar-cane white grub. The writer is not aware that any detailed experiments were carried out with the wasps with grubs in captivity, but about a hundred of them were released in a grub-infested region on one of the Aguirre *haciendas*, where it is possible they may breed.

In addition to the Scoliidae there are other types of parasites which would be met with during the search for the wasps, and among these are flies which attack both the larvae and adults of the Lamellicornia. Mr. Wolcott has informed the writer of the existence in Haiti of a Tachinid fly, *Ptilodexia harpasa*, Walk, which parasitizes the larvae of *Lachnosterna hogardi*, Blanchard, a beetle very closely related to *L. portoricensis* and *L. vandinei.*

An account of *Ptilodexia harpasa* is given by Dr. J. J. Davis in his "Contributions to a Knowledge of the Natural Enemies of *Phyllophaga*" (Illinois State Natural History Survey, Bulletin, Vol. XIII, Art. V, pp. 82–84, 1919). Dr. Davis remarks that "This fly, first recorded as a white-grub parasite under the name *tibialis*, has a wide distribution, occurring, according to published records, in Nova Scotia and Ontario, Can.; and in New Hampshire, New Jersey, Minnesota, Texas and New Mexico." This parasite, then, has a range extending from Southern Canada to Haiti in the Greater Antilles. It seems quite logical to suppose that an insect which exists under such a wide range of climatic conditions, and which works upon many different species of *Lachnosterna*, including both temperate and tropical species, would be easily adaptable to Porto Rican conditions. The writer believes that *Pt. harpasa* is the most likely of all foreign Diptera to become established in this Island, and hopes to attempt its introduction from Haiti at some time in the future.

CONCLUSION

The writer makes no claim that the present paper is a complete treatise upon the subjects dealt with. Many aspects deserving of deeper consideration have, of necessity, been but briefly touched upon, and much yet remains to be elucidated before we can tell what are the possibilities of the line of control here suggested and advocated as being adopted against one of most serious pests of Porto Rico's major crop.

It is hoped, nevertheless, that the present effort may serve to summarise in a general way and in a convenient form what is known of the Porto Rican Cane-grubs and their natural enemies, particularly the Scoliid wasps, and that this paper may prove of some use to future workers in this most interesting and promising line of inquiry and to those engaged in similar problems elsewhere.

The failure to obtain immediate results with the breeding of native and the introduction of foreign parasites should not discourage further attempts from being made, but should serve to stimulate interest until the right parasites have been found, as they inevitably will be if the work is started and continued in an intelligent and determined manner. It is most improbable that the cane-grubs of Porto Rico can be controlled by any one species of parasites, the ideal being to have parasites for each stage of their existence. A well-organized campaign, under good administration and with no lack of funds, should produce results within a few years sufficient to defray all expenses and leave a substantial balance in the pockets of the planters.

The entire cost of establishing properly equipped laboratories on the north and south of Porto Rico, together with a good library and all other necessities at whichever was made headquarters, as well as all travelling expenses in connection with the search for parasites abroad and at home, could be borne by a tax of 25 cents for every acre under cane cultivation the first year, and considerably less during subsequent years.

The sugar industry of Porto Rico loses not less than *three million dollars every year through the ravages of stalk-borers*, and to this must be added the loss due to white-grubs and weevil root-borer, so that *five million dollars would not be a too high estimate of the Island's annual loss through sugar-cane pests.* Many prominent sugar companies have been known to install outfits and processes in the mill at considerable cost, to increase the sugar output by about

0.1 per cent or even less; and frequently these are done as a speculation. Surely, then, some similar investment might be made in the *field* (for, after all, the raw product—sugar cane—is the basis of the entire industry) which would probably yield a bigger percentage of gain at less cost in the long run.

ACKNOWLEDGEMENTS

The kindness of Mr. C. L. Carpenter, Vice-President and General Manager, Central Aguirre Sugar Company, in giving permission to record in this paper the data and observations secured by the writer since he has been associated with this Company, is here acknowledged with many thanks.

It is desired to acknowledged the courtesy of Dr. Melville T. Cook, Chief of the Division of Botany and Pathology of the Insular Experiment Station of Porto Rico, in supplying the writer with several plant names, without which certain sections of this paper would have been incomplete.

Dr. H. L. Dozier, until recently Chief of the Division of Entomology of the same institution, very kindly prepared the photographs which are reproduced as Figs. 6, A and B; 7, A; 16, A and B; 19, A and B, and 21, A and B.

To the Administrator of Central Romana, Inc., Romana, R. D., the writer is indebted for many courtesies extended to him during a week's stay on their properties during July, 1925, and for providing every facility towards furthering the work upon which he was engaged.

Due credit and the writer's thanks should be given to Mr. D. M. Wilson, of the Central Aguirre Sugar Company, for having assisted by executing the diagrams on Plates I and III.

This paper would be incomplete without a word of appreciation to the Department of Agriculture of Porto Rico, for publishing this article in its very excellent Journal, and to Mr. F. A. López Domínguez, Secretary of the Sugar Technologists' Association of Porto Rico, for having recommended its acceptance.

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Appendix I

(Note.—In the following, an asterisk (*) signifies that the Scoliid is not actually known to parasitize the grubs under field conditions, but has been found to do so experimentally.)

A. Porto Rican Cane-grubs and their Scoliid Parasites, Where Known.

Lachnosterna portoricensis, Sm.

  Parasites:

    Dielis trifasciata, F.

    Dielis dorsata, F.

    * *Dielis pyrura*, Roh.

    * *Elis xanthonotus*, Roh.

Lachnosterna vandinei, Sm

Parasites:
Unknown, probably the same as above.
Lachnosterna guanicana, Sm.
Parasites:
Unknown.
Phytalus apicalis, Blanch.
Parasite:
Elis haemorrhoidalis, F.
Strataegus titanus, F.
Parasite:
* *Dielis atrata*, F.
Ligyrus tumulosus, Burm.
Parasite:
Dielis dorsata, F.

B. Porto Rican Scoliid Wasps and their Hosts, Where Known.

Elis haemorrhoidalis, F.
Host:
Phytalus apicalis, Blach.
Elis xanthonotus, Roh.
Host:
* *Lachnosterna portoricensis*, Sm.
Dielis atrata, F.
Host:
* *Strataegus titanus*, F.
Dielis dorsata, F.
Hosts:
Ligyrus tumulosus, Burm.
Lachnosterna portoricensis, Sm.
Dielis pyrura, Roh.
Host:
* *Lachnosterna portoricensis*, Sm.
Dielis trifasciata, F.
Host:
Lachnosterna portoricensis, Sm.

APPENDIX II

LIST OF THE SCOLIIDAE OF THE WEST INDIES AND BRITISH GUIANA

The writer is greatly indebted to the Imperial Bureau of Entomology, London, England, for supplying the names of the majority of the species listed below, these being represented by specimens in the collections of the British Museum (Natural History), whence the names were obtained. The list is as complete as the writer is able to make it.

Elis haemorrhoidalis, F.—Porto Rico.
E. ephippium, F.—Porto Rico, Santo Domingo, Antigua, St. Thomas.

E. nitida, Sm.—Porto Rico, Santo Domingo, Haiti, Cuba, Jamaica.
E. bodkini, Turn.—Demerara.
E. flavopicta, Sm.—British Guiana.
E. xanthonotus, Roh. (? syn. *ephippium,* F.)—Porto Rico, Santo Domingo.
E. sp. incert. (undetermined)—Santo Domingo.
Pterombus williamsi, Turn.—Demerara.
Tiphia cameroni, D. T., var.—Grenada.
T. Nitida, Sm.—Jamaica, St. Vincent.
T. argentipes, Cress.—Porto Rico, Cuba, St. Vincent.
T. parallela, Sm.—Barbados, Antigua, British Guiana.
T. punctata, Robt.—Santo Domingo.
Scolia (Discolia) guttata, Burm.—Trinidad.
S. plumipes, Dru.—Porto Rico.
Dielis atrata, F.—Porto Rico, Santo Domingo, Cuba, Jamaica.
D. peregrina, Lep.—Dominica, Tobago.
D. pyrura, Roh.—Porto Rico, Santo Domingo, Haiti.
D. costalis, Lep.—British Guiana.
D. trifasciata, F.—Porto Rico, Santo Domingo, Haiti, Cuba, Jamaica.
D. maculata, Dru.—Porto Rico.
D. tricincta, F.—Porto Rico, Santo Domingo, Cuba, Jamaica.
D. tricincta, F., var.—Trinidad.
D. dorsata, F.—Porto Rico, Barbados, British Guiana.

AN OUTBREAK OF THE RED-STRIPED SUGAR-CANE SCALE

By H. L. Dozier, Chief Entomologist, Insular Experiment Station

One of the most interesting occurrences of the past year was the serious outbreak of a scale insect on sugar cane near Arecibo, something heretofore unknown to have occurred on the Island. This scale, upon study, was found to be *Pulvinaria iceryi* Guérin, a species of which six individuals were reported on leaves of sugar cane at Cayey and Trujillo Alto. It was also reported by Smyth as being abundant in 1919 on his cane grown in the greenhouse where possibly it was protected from its natural enemies. Smyth also reported an apparent 6.6 per cent success in transmitting mosaic with this insect, but his experiments need repeating under better control conditions for substantiation. In addition to Porto Rico, the species has been recorded from British Guiana, Mauritius, and the Reunion Islands. The U. S. Bureau of Entomology has received specimens of this species from the southern part of Georgia (U. S. A.) on sugar cane on several occasions.

It seems rather surprising that this species, after being so long present on the Island, should now suddenly show up in epidemic form. The only theory the writer can advance is that the species which has heretofore been held in check by its parasites was at last enabled to gain the upper hand by a sudden upset in the "balance of nature". This theory is upheld by a study of the internal hymenopterous parasites attacking this species during the outbreak.

THE RED-STRIPED SUGAR-CANE SCALE

(*Pulvinaria iceryi* Guérin = *elongata* Newstead.)

On May 27th, 1925, a trip was made by the writer to Arecibo to investigate a reported oubreak of a scale insect attacking sugar-cane. It was found that an unfamiliar scale had attacked a block of forty-five *cuerdas* of young Rayada cane on the farm of Sr. Juan Santos, a colono of the Central Cambalache, about six kilometers from Arecibo on the main highway towards Mayagüez. This insect had been first noticed by Señor José Oliver the latter part of April in a piece of first-ratoon cane, three months after cutting. At that time an average of about one hundred female scales were found to the stool over an area of about five *cuerdas*. This cane had been cut

FIG. 1.—The Red-striped Sugar-cane scale *Pulvinaria iceryi* Guérin = *elongata*, Newstand, on sugar-cane leaves. About natural size. (Dozier)

the first of February and was attacked as it ratooned. The cut cane from this field had yielded better than thirty-five tons per *cuerda* average over the forty-five *cuerdas*. By the 7th of April the insect was found over the entire forty-five *cuerdas*. This entire field was then sprayed by the owner, using the old kerosene oil emulsion formula, one part of the stock to ten of water, and applied with a hand sprayer, about thirty stock gallons being used on this application. The cane foliage was not burned and apparently the application gave some good results.

On the day that the Entomologist inspected this field it appeared distinctly yellow in comparison with the other fields adjacent and in certain areas a large number of the older leaves were dead and dying and fairly well infested with the adult mother scales, beneath which were found large numbers of eggs and numerous newly hatched young. The young larvae were very abundant, settling on the new foliage, and giving promise of more serious damage later. For the three months previous to this time no rain had fallen in that section and this sudden outbreak might have been connected in some way with this extremely dry period.

Again, on June 26th, the writer made a survey of conditions and found that the insect was continuing its damage and in about as abundant numbers as before. At this time the adult females of what was probably the third generation were very abundant and newly hatched crawlers were infesting the new foliage. A strip of about four *cuerdas* of this field was almost a complete loss and active spray measures were being taken against the remainder.

DESCRIPTION AND LIFE HISTORY

The full-grown female scale is very much elongated, measuring 6.50 mm. in length and 2.50 mm. at its greatest width, and although rather flat as a whole is distinctly raised or convex with the surface entirely smooth. It is of a testaceous-yellow color with two rather narrow but well-separated, distinct reddish stripes running almost parallel for most of the body length. These two stripes make their appearance early in the life of the scale, being more or less distinct in the second instar larva and becoming more conspicuous and prominent as the scale matures. These two reddish stripes serve as a ready means of identification and distinguish it from all of the other scales known in Porto Rico. At times the sides of the full-grown scale have a more or less diffusion of reddish vein-like markings outward from the two median longitudinal stripes. After young are produced these two reddish lines break up into rather faint irregular brownish markings, leaving the scale covering for the most part a testaceous-yellow in color.

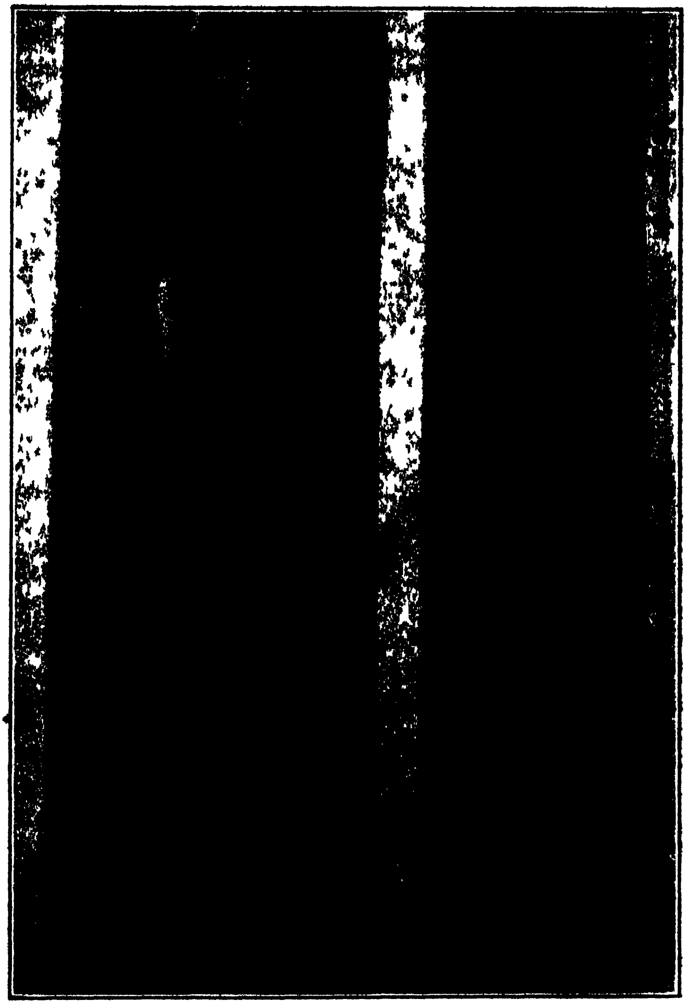

FIG. 2.—The Red-Striped Sugar-cane Scale, *Pulvinaria iceryi* Guérin = *elongata* Newstand, on Sugar-cane leaves. About 2 times natural size. (Dozier)

The full-grown and mature female forms a cottony or mealy excretion beneath the scale covering which together with the sugar-cane leaf forms an ovisac and serves as a protection in which the eggs are deposited and where the young are protected after hatching until they issue out from under the mother scale covering. The eggs are elongate-elliptical in shape, about twice as long as wide at the greatest width, measuring 0.416 mm. in length by 0.224 mm. width, and are of a pale dirty white color. Over one hundred eggs were counted beneath one scale.

The male scale of this species is still unknown although a careful search has been made and much material put up in emergence boxes. In fact it seems that this species must reproduce itself parthenogenetically, that is, without the necessity of being first fertilized by the male.

The newly hatched larva or "crawler" is a testaceous-yellow in color, elongate-oval in outline, measuring 0.528 mm. in length by 0.208 mm. width, with a pair of antennæ or feeler and a pair of long filaments projecting from its hind end. The feet are well developed and the larvæ of most of the stages are very active and frequently change their feeding position on the leaf. In the last instar, however, the full-grown scale is stationary. The newly hatched crawlers react very positively to light and their favorite settling place is along the leaf in the lengthwise depressions and in most cases on the underside of the leaves. Very rarely do they settle and feed along the stalk of the plant.

NATURAL ENEMIES

Adults and young of the ladybird beetle, *Cryptolaemus montrouzieri*, were abundant over the field feeding on the scales of various sizes and many were noticed feeding beneath the adult female scales where they had pushed them up off of the leaf. This beetle was imported from California into Porto Rico by Van Dine in 1911, bred in numbers and turned loose at various points on the Island, and is now after many years proving itself a very beneficial insect, attacking many species of scale insects here.

Material of this scale was placed in parasite-rearing boxes at the time of the first investigation with the result that three species of hymenopterous parasites were reared, a primary parasite, *Aphycus flavus* How; a secondary parasite upon this species, evidently *Cheiloneurus pulvinariae* Dozier; and a few spesimens of a coccophagine, *Aneristus ceroplastæ* How. Later, from more material collected in July the most abundant parasite reared was *Aneristus ceroplastæ* and it was proved by dissecting the adult female scales that this was a primary parasite. In examining parasitized scales some were found with as high as seven and eight emergence holes in them. Out of

275 scales examined on July 10th, 71 were found parasitized, or only 28.7 per cent. With the first batch of material the *Cheiloneurus* was far more abundant than either of the primary parasites, a fact that probably accounts for the rapid rise and spread of the scale without effective natural control.

The following descriptions and drawings are given to enable ready identification of the species of parasites concerned.

Aphycus (*Euaphycus*) *flavus* How.

The writer is indebted to Mr. P. H. Timberlake who, in making the identification of this species, states that although the type of *flavus* has apparently been lost, these specimens agree with what has gone in literature in past years as typical *flavus*.

Female: The frontovertex is about twice as long as wide; the ocelli placed in an acute-angled triangle, the posterior pair close to the margin of the eyes. Antennae inserted near the mouth. Antennal scape flattened and narrow, four times as long as wide at greatest width near the middle, pedicel as long as the first three funicle joints combined; first four funicle joint subequal in length and breadth, the fifth slightly longer and the sixth distinctly longer; fifth and sixth increasing in width so that the sixth is nearly twice as wide as the first joint; club three-jointed, a little wider than the last funicle joint and nearly as long as the last five funicle joints combined. Forewings typical with the oblique hairless streak widened and interrupted below. Hind wings short, the marginal hairs relatively long. Abdomen shorter than the thorax and of about the same width.

General color of upper surface of body an orange yellow, the legs and underpart a paler yellow. Pronotum pale yellow with a fuscous dot on each corner. Antennae yellow, a longitudinal streak or spot on the upper margin of outer surface of the scape towards its apex, the base of pedicel, the first three funicle joints, and the basal half of club, fuscous; the club a yellowish-white in apical half. Legs a uniform pale yellowish, the tarsal claws blackish. Wings hyaline with the veins yellowish.

Length, exclusive of ovipositor, 0.70–1.20 mm.

Male: Similar in coloration to the female except that the metanotum, propodeum and dorsum of abdomen, especially towards apex, are embrowned. Antennae also similar in structure except that the joints all increase in width successively, the club is not three-jointed as in female; the entire flagellum is uniformly dusky.

Length, 0.640–0.840 mm.

Reared in abundant numbers as a primary parasite from *Pulvi-*

naria iceryi on sugar cane at Arecibo, P. R., during May and July, 1925. *Aphycus flavus* has been recorded by various workers as being reared from *Toumayella liriodendri, Tachardia* sp., *Pulvinaria pyriformis, Coccus hesperidum, Chrysomphalus dictyospermi, Aspidiotus hederae,* and *Saissetia oleae.*

Cheiloneurus pulvinariae n. sp.

In the female sex this species resembles most closely *C. inimicus* Compere, but is distinguished by its distinctly smaller size, its lack of a black line on the ventral margin of scape, by having no metallic color on propodeum, and difference in wing venation. The male is more easily distinguished by having the eyes hairy, and the first funicle joint much longer and with more hair.

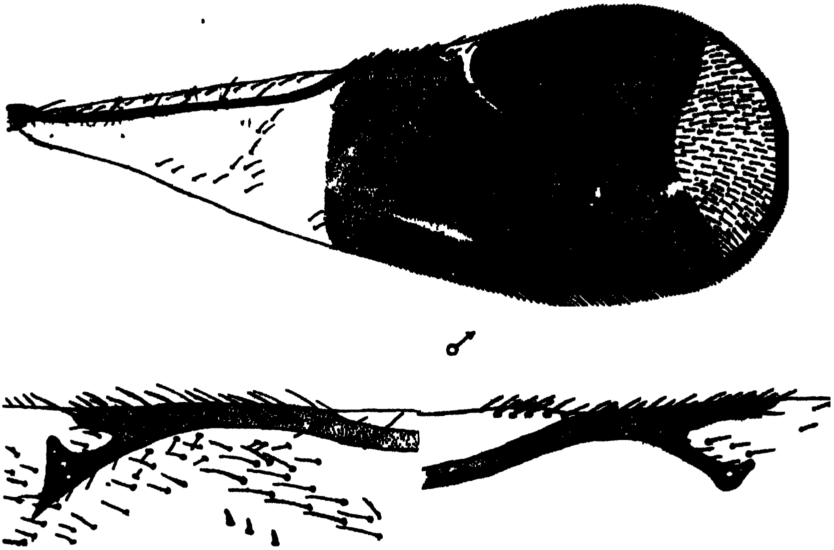

FIG. 3.—*Cheiloneurus pulvinariae* n. sp. **Above, wing of female. Below, venation of forewing of male and female, much enlarged.** (Dozier)

Female: Head about one and one-half times wider than long; ocelli arranged in an acutely-angled triangle. Antennal scape slightly expanded below, nearly three times as long as widest width; pedicel triangular, as long as the first two funicle joints combined; funicle joints gradually widen so that the sixth is almost twice as wide as the first; first four joints of funicle about equal in length, the sixth a fourth longer than the fifth. Club three-jointed, oblongate, slightly wider than the scape and about the same length. Mesothoracic scutum about twice as wide as long. Scutellum only slightly wider than long with the characteristic tuft of black bristles. Pronotum and mesoscutum very finely reticulated, with numerous setigerous punctures, the punctures of the silvered area being larger and elongate; mesoscutum set with eight strong blackish hairs on hind margin; the scutellum is more distinctly and coarsely reticulated. Abdomen about same length as the thorax, with ovipositor sheath slightly exserted. Wing with characteristic embrowning and venation as in Fig. 5.

General color yellowish-orange. Eyes dark. Antennal scape soiled yellowish with the margins slightly embrowned; the pedicel and first three funicle joints more or less distinctly fuscous, varying greatly in slide-mounted material; hairs of the first three joints darker and more prominent than those of the other funicle joints; fourth, fifth and sixth joints a testaceous-yellow. Mesoscutum testaceous yellow with two more or less distinct longitudinal, more orange-colored stripes passing through its length onto the scutellum, in slide-mounted specimens. The posterior third is crossed by a broad dark band that is overlain with an iridescent silvery sheen. Scutellum, metanotum, and propodeum yellowish with slightly darker color than the mesoscutum. Abdomen dirty yellowish with the basal segments and the apex of the last segment embrowned. Femora and tibiæ testaceous-yellow, with varying degree of fuscous markings, forelegs with only slight infuscation along the dorsal margin of femora towards apex; middle legs with infuscation dorsally near knee; hind legs with dorsal sides of femora infuscated, the tibiæ with a more or less distinct band across width on upper third and a blotch on disc of lower third, fuscous; all tarsi testaceous, the claws dusky.

Length, exclusive of ovipositor, 1–1.10 mm.

Male: Antenae entirely different from those of female: scape long and slender, the pedicel very short, much shorter than the first funicle joint; funicle joints each distinctly narrowed towards distal end and furnished with partial whorls of long, diverging hairs as in illustration. The hairs on scutellum are not in a tuft as in female sex. Pronotum, mesoscutum, axillæ, and scutellum distinctly reticulated.

General color a dark brown, the legs lighter in part. Antennae with scape pale, the margins slightly embrowned the pedicel distinctly dark, and the flagellum uniformly light brown. Wings hyaline without markings.

Length, 1–1.08 mm.

Described from a series of balsam-mounted specimens, twelve females and two males May 28-31, 1925, one female and one male June 6, 1925, and two females and three males July 10, 1925; all reared by the writer from *Pulvinaria iceryi* during severe outbreak of this scale on sugar cane at Arecibo. It seems certain that this is a hyperparasite on the primary parasite of this scale, *Aphycus flavus*, with which it was always reared.

Types deposited in U. S. National Museum; paratype material in collections of the writer, P. H. Timberlake, and the Porto Rican Insular Experiment Station.

The adult of the following parasite is very active and carries its abdomen at an elevated angle, a mannerism which is very characteristic of this species.

Aneristus ceroplastæ How.

This species, the only American representative of the genus, was first described in 1895 from two female specimens reared by T. D.

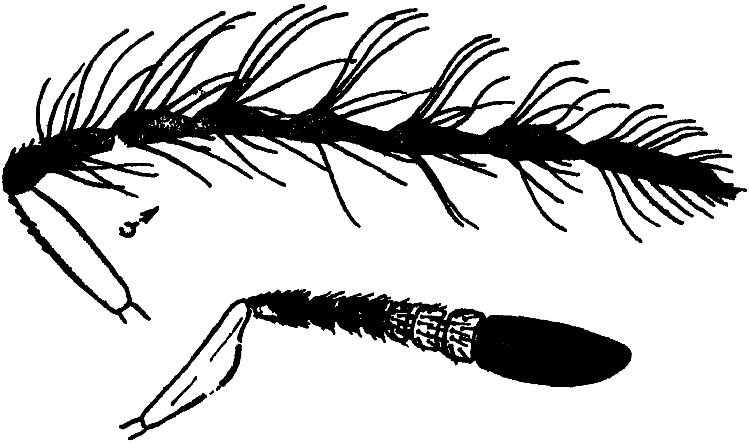

FIG. 4.—*Cheiloneurus pulvinaria* n. sp. Above, antenna of male. Below, antenna of female. Much enlarged. (Dozier)

A. Cockerell from *Ceroplastes* sp. on *Euphorbia hypericifolia* from Jamaica. Again in the same year Dr. Howard described *Coccophagus orientalis* from thirteen females reared by E. E. Green at Pundulaya, Ceylon, from *Ceroplastes actiniformis*, *Lecanium viridis*, *Lecanium coffeæ*, and *Dactylopius adonidum*, with the statement that it "seems to be an abundant and general scale insect parasite in Ceylon". According to Timberlake *Coccophagus orientalis* is a synonym of *Aneristus ceroplastæ*, and the species is widely distributed in the Tropics, occurring in Hawaii, Philippines, Java, India, and the West Indies. A female of this species was reared by the writer in New Orleans, La., from *Coccus hesperidum* material on citrus, January 15, 1925. The male has not yet been described and the writer deems it best to give here a full description of both sexes.

Female: Resembles greatly a *Coccophagus*, being distinguished from members of that genus only by the shape and structure of the posterior tibiae. Head slightly wider than long. Eyes rather large, with scattered microscopic hairs. Ocelli placed in an equilateral triangle. Lateral and hind margins of vertex with prominent black bristles, the dorsal surface with smaller black bristles scattered over the surface. Upper surface of vertex somewhat coarse, the cells being pentagonal or quadrate, but with each hind corner at eyes the pattern becomes longer and more transversely drawn out. Scrobes deep and about as wide and long at the antennal scape. Antennae with scape about equal in length to the pedicel and first two funicle joints, inserted just above the mouth and reaching to middle of the face, somewhat flattened from the side, under high power large and coarsely reticulated; pedicel short, triangular, slightly longer than wide, distinctly and coarsely reticulated. The entire flagellum very much flattened with the longitudinal elevations very strong and numerous. First funicle joint twice as long as pedicel, somewhat longer than broad, slightly longer than the second; the second and third funicle joints each successively shorter but of about the same width; joints of funicle supplied with numerous stout bristles. Club distinctly three jointed, with the first joint a little broader than the funicle joints, the second and third successively diminishing in width, all joints subequal in length, the last tapering to a blunt point. Thorax shagreened and rather densely set with stout black bristles, under high power with distinct and coarse reticulated pattern on dorsum with exception of the propodeum. Forewings nearly two and a half times as long as broad, the surface set with bristles which are much stronger and more prominent on the clouded area; marginal vein very long and straight, the stigma very short. Legs with the hind femora very large and flattened, the hind tibiae also much flattened with a distinct row of short stiff bristles along outer margin; middle tibial spur about as long as the first tarsal joint, which is decidedly longer than the first two tarsal joints combined.

General color is black with slight purplish reflections. Antennae dark brown with exception of the light colored scape. Wings hyaline, the forewings with a large discal fuscous blotch that extends completely across width of the wing. Legs blackish-brown, the tarsi and tibiae of front legs whitish; posterior half of middle tibiae also whitish.

Length, exclusive of ovipositor, 0.940–1.20 mm.

The male differs from the female in having the forewings entirely hyaline and the antenae pale in color; otherwise about the same as female in structure and coloration.

Length 0.7–.760 mm.

The writer has reared this species from *Ceroplastes cirripediformis* material on *Ficus*, June 28, 1925, at Santurce; from same scale on Passion flower vine at Bayamón, July 3, 1925; from *Saissettia haemisphaeria* on avocado, June 16–18, 1925, at Río Piedras; from *Eucalymnatus tessellatus* on *Calophyllum antillarum,* June 21, 1925, at Santurce; and in large numbers from *Pulvinaria iceryi* on sugar cane at Arecibo. Of twenty-four specimens mounted, only five were males, showing a large preponderance of females, at least during those months. On July 10th many of the black pupae of this species were dissected out, the characteristic antennae making identification easy. They occurred only one to a scale, causing a characteristic blackened area to appear which easily distinguished the parasitized scales from the normal healthy ones.

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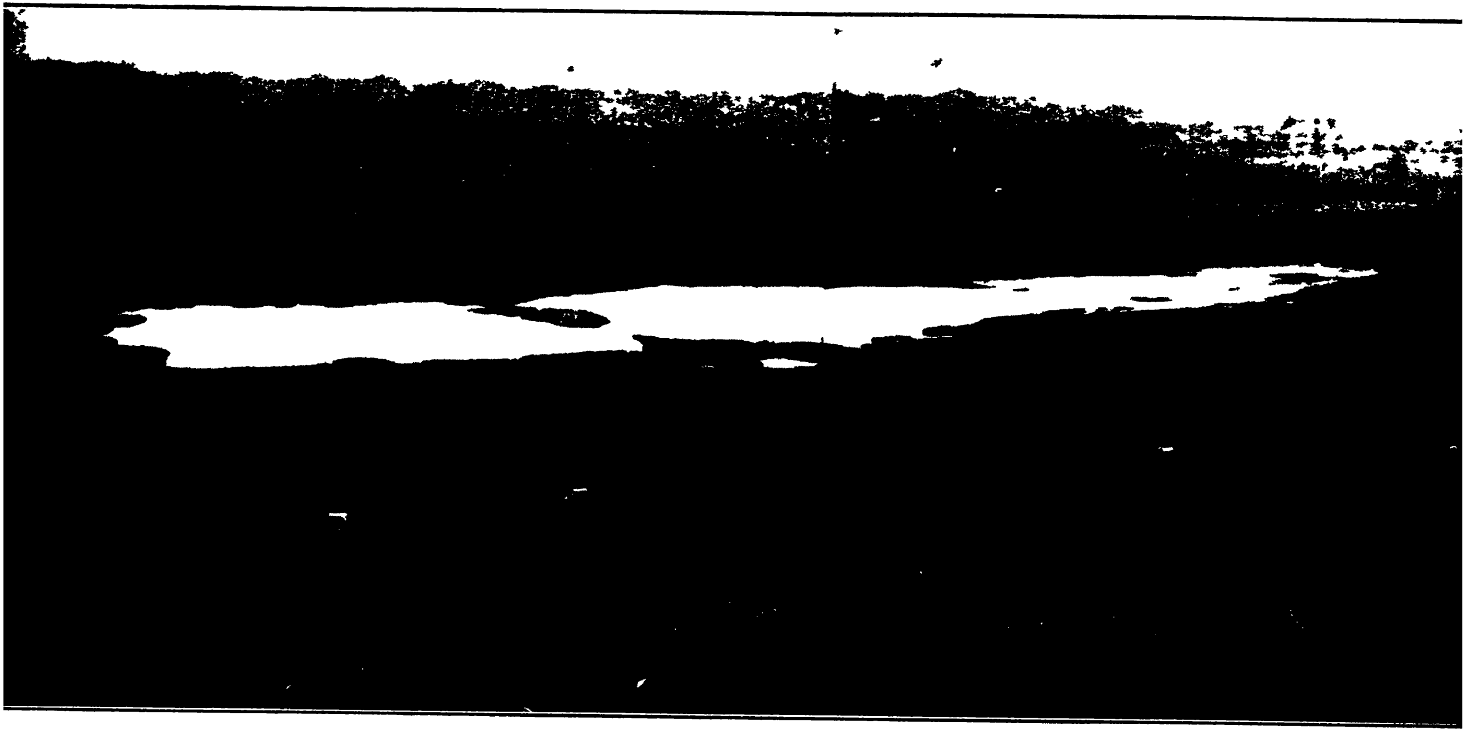

FIG 2—Cartagena Lagoon from Tinaja Hill

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AN ECOLOGICAL STUDY OF CARTAGENA LAGOON, PORTO RICO, WITH SPECIAL REFERENCE TO THE BIRDS[1]

FOREWORD

By STUART T. DANFORTH

The ultimate aim of Ornithology, to my mind, is to make use of birds to the limit of their capacity as servants of man. I believe that eventually we will know so well how to encourage and protect birds that they will be practically one hundred per cent efficient in protecting our forests and crops from insect pests, and that poisonous sprays and other protective measures will be unnecessary in the vast majority of cases. But before we can know how to use birds to their best advantage it is necessary to learn almost countless things about them. First of all we must know which birds are injurious and which beneficial, and in what ways they are beneficial. For this we must have a complete knowledge of their food. We must learn in detail what particular habitat each species prefers, and what kind of a situation it requires for nesting. We must know what the enemies of each species are, and how they can be controlled. We must have exact information about the breeding season of each species. We must know the innumerable interrelations of each species with its neighbors and its environment. Indeed, there is almost no end to the facts which must be known about each species before it can be utilized to its fullest extent, and one never knows what seemingly insignificant bit of information may eventually prove to be of the most importance. The investigation upon which this paper is based was undertaken with the desire of discovering as many of these facts about a much-neglected group of Porto Rican birds as possible within the available time, and it is hoped that eventually our information will be so complete that they may be utilized to the fullest extent But we do not have to wait until that time to begin deriving benefits from them. We already know enough about them to utilize them much more fully than we do at present. Many of the most useful species in Porto Rico are sadly in need of more complete and efficient protection. Better game laws are necessary, and strict enforcement of those already in effect if many species are to be prevented from extermination or from becoming excessively rare. Sixteen species of West Indian birds are already extinct and many others are verging upon extinction. It is to be hoped that the people of Porto Rico will act before it is too late to save some of its most valuable bird inhabitants.

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[1] A thesis presented to the faculty of Cornell University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

The field work upon which this paper is based was done during twenty months spent in Porto Rico. During the first period of nine months from October, 1921, to the last of June, 1922, bird work was of necessity confined to Saturdays and occasional holidays. During the second period of eleven months, from November, 1923, to October 1924, the whole time was devoted to Ornithology and related field work with the exception of an occasional week in which attacks of fever prevented work. During such a short period it is impractical to work intensively in a large area. Therefore Cartagena Lagoon, which is at present the most important wildfowl resort in Porto Rico, was chosen as the chief field of my labors. Bird work done at other places on the Island was merely incidental.

The author wishes to express his appreciation to Professor A. A. Allen for his helpful advice and guidance throughout his work in Porto Rico and the preparation of this manuscript; to Professor A. H. Wright for his help and encouragement; to Professor O. D von Engeln for his assistance in interpreting the physiographical aspects of the work and for his encouragement; to Dr. N L. Britton of the New York Botanical Gardens for identifying most of the plants; to Dr Karl P Schmidt of the Field Museum of Natural History for his helpful advice and kindly interest in the herpetological phase of the problem; to Mr L L. Buchanan of the Biological Survey, Mr A. J Mutchler of the American Museum of Natural History, Mr. James A G Rehn of the Academy of Natural Sciences of Philadelphia, Mr George N Wolcott, formerly of the Porto Rico insular Experiment Station, Mr W L McAtee of the Biological Survey, and to Mr. H G. Barber of Roselle, N. J., each of whom has identified one or more insects which are mentioned in this paper; to Dr Mary J. Rathbun of the U S National Museum for identification of the Crustacea; and to Dr A Alvarez of Mayagüez, P. R, and Mr. Luis H. Mendoza of Cabo Rojo, P. R., for sending me certain additional specimens for which necessity arose during the writing of this paper Others too numerous to mention have aided in one way or another, and to them also I wish to express my appreciation for their valued assistance.

PART I

GENERAL ACCOUNT OF PORTO RICO

Porto Rico is the smallest and easternmost of the Greater Antilles. It lies between 17°54′ and 18°33′ North Latitude and between 65°13′ and 67°16′ West Longiture. It is in the same latitude as Jamaica, British Honduras and the northern part of Guatemala. It is about 1,450 miles from New York, and 450 miles from the nearest part of Venezuela. The Island is nearly rectangular, 113 miles long and 40 miles wide. Its area is 3,670 square miles, which is about four fifths that of Jamaica, seven-tenths that of Connecticut, or three times that of Rhode Island. The coast line measures about 360 miles, the north and south sides being nearly parallel, while the east and west shores are more irregular. The northern coast of Porto Rico rises abruptly from the sea, in fact Brownson's Deep, which is 24,000 feet in depth, and said to be the deepest spot in the Atlantic Ocean, lies less than 100 miles north of Porto Rico. Slightly further to the south of Porto Rico, in the Caribbean Sea, lies Tanner's Deep, extending 15,000 feet downward Thus Porto Rico may be regarded as a badly eroded summit region of a great mountain mass.

Almost the entire surface of the island is covered with mountains of various heights and shapes without any apparent system of arrangement Most of them are not very high. The highest peak is El Yunque (in the northeastern part of the Island), which rises to a height of 4,895 feet. The only other peaks which are known to exceed 4,000 feet are a few near Jayuya, in the center of the Island, one of which, unnamed on the maps, reaches a height of 4,440 feet. Notwithstanding this apparently confused arrangement of the mountains there is a distinct watershed which divides the Island into two unequal parts This divide extends from Mayagüez on the west to Humacao on the east, with a branch extending northeastward to El Yunque. The part of the divide from Mayagüez east to Aibonito is known as the "Cordillera Central"; that from Humacao to Aibonito as the "Sierra de Cayey", and that from El Yunque to Humacao as the "Sierra de Luquillo". About one third of the Island is south of this divide and two-thirds north of it. In places the mountains and sea meet abruptly, but in most places there is a narrow coastal plain, and a few broad valleys extend well inland.

There are no lakes in the mountainous interior of the Island except the recently completed Guayabal Reservoir near Villalba. In the coastal plain are some salt-water bayous and mangrove swamps, and a few more or less temporary fresh-water lagoons, which will be discussed at length later in this paper.

Porto Rico and the other Antilles were, according to geologists, formerly joined to each other and to North America, forming a continent known as Antillea. Then a great subsidence occurred, leaving only the mountain tops above water. After awhile an uplift took place, and the old continent reappeared. The sediments which appeared during the period of submergence were then folded into huge mountain systems. Then came another but lesser subsidence which resulted in breaking up the continent into the island groups as they occur at present. Jamaica was the first to be separated, then Cuba, and afterwards Haiti and Porto Rico.

The central mountains are composed mainly of volcanic materials (tufas and conglomerates), which have been sorted and laid by water, with occasional intrusions of blue limestone. They are mainly of Cretaceous age. All the rock material is weathered at the surface in the humid regions, due to the great amount of precipitation and the high temperature, forming a deep mantle of red clay, which is so tenacious that it can maintain itself in an almost vertical position. The foothills are white limestone of marine origin, and are all of late Tertiary and Pleistocene age. The coastal plain deposits are alluvial formations, usually of a rich, dark-brown sandy loam.

PHYSIOGRAPHIC HISTORY OF PORTO RICO

According to Lobeck (1922) Porto Rico is probably essentially a block or horst bounded by faults. The oldland was a complex mountain mass composed of igneous rocks. Under the influence of subaërial erosion this oldland was reduced to a rather perfect peneplain except for two groups of Monadnocks, which are the Luquillo Mountains at the east of the Island, and the Cordillera Central, which crosses the Island from east to west. This first peneplain was then uplifted, and a new cycle of erosion started. Then a submergence occurred and a coastal plain was deposited on the north and south sides of Porto Rico. Another uplift then occurred, and initiated the dissection of both the coastal plains. After this dissection the entire coast suffered a slight submergence, supposed to have been caused by the melting of the continental glaciers at the close of the Glacial Period. Recent changes which have taken place since this submergence include the deposition of alluvium along stream courses; the building of extensive alluvial fans along the south coast, and the silting up of bays. Finally there is some evidence of a slight emergence now taking place.

CLIMATE OF PORTO RICO

Although Porto Rico is well within the tropics, its climate, except that of the west end, is not so torrid as might be expected, as it is modified by the North Atlantic trade winds, of which it is in the direct path. These trade winds blow from the northeast with remarkable constancy throughout the year, so they have but little effect on the western end of the Island. Their velocity rarely varies from a yearly average of eleven miles per hour, except in July, when the velocity increases to thirteen miles, and in October and November, when it falls to about nine miles. March is also a month of very light winds.

Thunderstorms are not very frequent, nor are they usually very violent. On very rare occasions they are accompanied by hail.

Many hurricanes pass near Porto Rico, but the centers of few cross over the Island. The most notable of recent years were those of August 8, 1899 and September 13, 1921. In the summer of 1924 three passed close to Porto Rico, but brought only gentle wind and rain there. One of them did considerable damage in St. Thomas, eighty miles east of Porto Rico, but in the latter island the effects were scarcely noticeable.

The U. S. Weather Bureau records for more than forty stations show an annual average temperature of 76.3°. During the coldest winter months the average is 73°, and during the hottest summer it is 79°. The daily range of temperature is much greater than the seasonal. The difference between afternoon and early morning temperatures may be as great as 25°. The maximum temperatures range from 90° to 95° at the more elevated stations, and 95° to 104° along the coast and in the valleys. The minimum temperatures range from 50° to 55° at the higher elevations, while a minimum of 60° is rarely reached on the coast. The lowest recorded mountain temperature is 43°.

Porto Rico, small as it is, has a topography which causes an extreme variation in the amount of precipitation in different places almost if not quite as great as can be found in the whole of the United States. The entire south side is dry enough to make irrigation necessary to grow crops, the annual precipitation varying from

20 to 45 inches, while on the north side it ranges from 55 to 135 inches. The highest average rainfall is in the Luquillo Mountains (135 inches) with a maximum record in 1901 of 169 inches. On the south coast there is a record of thirteen months when not an inch of rain fell at Guayama, and of a period of three years when no rain fell at Cabo Rojo. The average number of days when rain falls for the Island as a whole is 169, with a minimum of 28 at Guánica and a maximum of 341 in the Luquillo Mountains.

The average humidity for the Island is about 78 per cent, varying from a minimum of 75 per cent in the driest month to a maximum of 81 per cent in the most humid month.

In many parts of the Island the rainy and dry seasons are not well defined. Rains may occur at any time of the year, although the minimum rainfall is in February and the maximum during the summer months.[1] In the western part of the Island the rainy and dry seasons are more distinct. In Mayagüez the rainy season is usually from May or June until November, although it is rather variable. In the semiarid southwestern part of the Island the rainy season is shorter, generally occurring from September to November. At Mayagüez occasional rains occur in winter, and there are often summer days without any rainfall.

EFFECT OF DENSE POPULATION ON WILD LIFE

The population of Porto Rico according to the census of 1922 was 1,299,809, or at the rate of 392.14 persons per square mile. This is a denser population than that of any state except Rhode Island, Massachusetts and New Jersey, and is not conducive to very favorable conditions for birds, particularly as 79.9 per cent of the population is rural. That the distribution of the population is remarkably even is shown by the fact that the centers of area and population are less than five miles apart. There are almost no spots on the Island where one can be out of sight of human habitations. Owing to this overpopulation, practically every foot of arable soil is under cultivation, even to the tops of many of the higher mountains, and very little of the original forest remains. Only four small tracts are known to me: One on El Yunque, another in the mountains near Maricao, the third a very small patch of private forest reservation on the north coast at Sardinera, and the fourth a still smaller patch south of Pueblo Viejo.

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[1] EDITOR'S NOTE.—Dr. Oliver L. Fassig, Chief of the West Indies Climatological Service, in his article "The Climate of Porto Rico" in "The Book of Porto Rico", page 29, says, referring to rainfall: "The maximum generally falls in September along the north coast, while in the mountains of the interior the time of maximum occurs in one of the summer months or as early as May."

BIRD LIFE OF PORTO RICO

The avifauna of the West Indies is noted for its paucity of species as compared with places in corresponding latitudes on the mainland. As might be expected, Porto Rico has even fewer species than the other Greater Antilles. This is on account of its smaller size and its comparative remoteness from continental land areas. Only about 150 species of birds are now found on the main Island of Porto Rico, and many of them are very rare or local in their distribution. Nearly 70 of the species are migrants, and 24 species are peculiar to Porto Rico. Although the species of birds are relatively few, the number of individuals is large, a certain few of the species, such as the Honey Creeper, the Gray Kingbird, the Porto Rican Grackle and the Carib Grassquit being exceedingly abundant. On the other hand, many species such as the Porto Rican Short-Eared Owl, Parrot, Crow, Limpkin and the Blue Pigeon are upon the verge of extinction. The owl and pigeon may already be extinct.

PART II

CARTAGENA LAGOON AND ITS FLORA AND FAUNA

CARTAGENA LAGOON

Geographically, Cartagena Lagoon is situated in the southwestern corner of Porto Rico, about two miles west of Lajas, five miles east of Boquerón, and a half a mile south of Desengaño switch on the Cabo Rojo branch of the American Railroad. Its latitude is 18°01′ North, its longitude 67°06′ West. The lagoon is approximately one and a third miles long and a half a mile wide, although at times of especially high water its extent may temporarily be somewhat greater.

Parts of Cartagena Lagoon are included in three different sugar estates The eastern end (east of a wire fence which crosses the lagoon), belongs to Señor Don Carlos Val; the remainder is owned by Señor Don Jacobo Cabassa, with the exception of a small area in the northwestern corner, which belongs to Señor Don Ernesto Forestier. The owners are at present considering draining the lagoon to convert it into canefields, but for the sake of the wild life of the Island it is to be hoped they will not do so. Unless water were brought from the mountains their venture would doubtless not be very successful, since under present conditions the growth of cane in the nearby field is dependent upon water pumped from the lagoon during a large part of the year.

The lagoon is situated in the broad Yauco-Boquerón anticlinal valley This is a rather remarkable valley twenty-one miles in length, and approximately three miles wide at its widest point. It runs in an east-west direction, and at present is not occupied by any stream in the greater part of its length, and only by the small and intermittent Boquerón River and its tributaries at its lower end. According to Mitchell (1918) this valley was eroded almost to its present extent before the Tertiary period by the action of a large stream having its sources in the mountains near Yauco. But then the Guanajibo River pushed its headwaters back and captured the streams which were flowing into the Yauco-Boquerón Valley, leaving it dry. Water gaps now mark the spots where this stream piracy took place. The southern side of this valley is a wall formed by San Germán limestone and tuff, but the northern boundary is less strongly set off from the low hills of the mountainous region. The valley is formed principally on tuff. To the north is a region of low hills, while to the south a single ridge of low hills separates the valley from the Caribbean Sea. Parts of Mariquita (or Tinaja) and Paquita Hills lie directly south of the lagoon. These hills are formed of San Germán limestone and Upper Cretaceous tuff, with streaks of Upper Cretaceous shale. Cartagena Lagoon is merely a low spot in this valley. The valley has a gentle slope from sea level at Boquerón, so that the elevation of the lagoon is about twenty feet above sea level.

Cartagena Lagoon has no inlet except immediately after a heavy rainfall when several small and temporary streams flow into it, and it has no regular outlets, although at times of very heavy rainfall it occasionally overflows, and its excess waters reach the tributaries of the Boquerón River, and flow thence to the sea.

Two other lagoons exist in this valley to the east of Cartagena Lagoon, namely Anegado and Guánica Lagoons. These are broader and shallower than Cartagena Lagoon, and are more irregular in the seasons at which they contain water. An extra rainy season may fill them up so much that they may contain water for over a year at a stretch, as in 1921 and 1922, or they may be dry for two or three consecutive years, as in 1923 and 1924. Much of the time the beds of these lagoons are so dry that clouds of dust are raised when a horse gallops across them. Cartagena Lagoon at its driest has an oozy mud bottom. In addition to the lagoons of the Yauco-Boquerón Valley I know of but one other fresh-water lagoon on the Island (Laguna Tortuguero, on the north coast). However, the recently constructed Guayabal Reservoir, near Villalba, forms a fresh-water lake of fair size.

The bottom of Cartagena Lagoon consists of alluvial clay which holds the water caught at times of heavy rainfall until it disappears almost solely by the process of evaporation, which is very rapid in this semiarid region. Nevertheless the lagoon catches so much water from each rainfall that it very seldom dries up completely. Until 1923 it had never been known to do so, but it dried up completely in the summer of 1923 and again in July 1924. In addition to the water which disappears by evaporation, much water is pumped from the lagoon during the drier parts of the year for irrigating the nearby canefields. Most of the pumping is done from March to September (in 1924 it was begun on March 11).

The reason for the semi-aridity which the region around Cartagena Lagoon shares with the entire southern coastal plain is that the prevailing northeast trade winds have to pass over the high Cordillera Central before reaching this part of the Island. The mountains extract the moisture from the winds, causing heavy precipitation on the mountains, and causing the winds to be drying rather than moisture-bearing winds when they reach the valley. Their drying effect is so great that on the coast two miles from the lagoon salt is made by the open-air evaporation of seawater. The extreme southwestern tip of the Island verges on actual aridity. According to the official records, for a period of three years no rain fell at Cabo Rojo Lighthouse.

At Cartagena Lagoon occasional showers occur at any season of the year, but very few of them outside of the rainy season bring sufficient precipitation to cause water to flow in the temporary streams which feed the lagoon. The rainy season, if such it can be called, begins in September and lasts until November. This does not mean that it rains very often in this period, but that it is during this period that the few heavy rainfalls which occur during the year always take place. During this period the lagoon always fills to the brim and sometimes to overflowing, and then the process of evaporation begins. Just before the beginning of the "rainy season" it is often nearly dry.

When the lagoon is full the water is five feet deep at the deepest part, while the average depth is from two to three feet. But underlying all is a layer of oozy mud varying from a few inches to four feet or more in depth. However, there are but few parts where it is unsafe to go on this account, and there are but few records of people having lost their lives. Pigs and goats, however, often become mired, especially when the lagoon is dry or nearly so, and the sun bakes a thin crust over the top of the mud which deceives the animals. In August, when the lagoon is at this stage, myriads of small migratory shorebirds sworm over its surface, and the waterfowl are forced to the extensive mangrove swamps and salt water lagoons of the coast. When the first showers of the rainy season, during the latter part of August or the early part of September, bring enough water for their needs they come trooping back, and it is the turn of the hordes of shorebirds to seek other and more hospitable regions.

PLANTS AND ANIMALS OF CARTAGENA LAGOON

PLANTS

In a study of bird ecology plant societies are one of the most important factors. Before discussing the distribution of the plants at the lagoon, however, a few general statements about the flora of the southwestern part of Porto Rico are pertinent. As this region is semi-arid, the vegetation is more sparse than in most parts of the Island. Except near the watercourses, which, of course, are only intermittent streams, tall trees are scarce, and most of the vegetation is brushy, much of it having quite a close superficial resemblance to the sage brush of the western states. Cacti abound on the higher land. and in places grow in profusion right to the edge of the sea. Cocoanut palms fringe the beaches, but are scarce farther inland. In places where the brush does not grow there are a number of species of drought-resisting grasses and herbaceous plants. Bamboos and fair-sized trees line many of the water courses, and occasional tall trees are found in other places. Porto Rican Royal Palms (*Roystonea borinqueña*), seem to resist drought fairly well, but are not nearly so common as they are in more humid regions.

At the lagoon the succession of the plant associations is quite distinct, though somewhat complicated by the great seasonal changes in the amount of water together with the fact that it is always the "growing season" for plants in Porto Rico.

Plant Associations of Cartagena Lagoon

1. THE OPEN WATER ASSOCIATION

This association includes the open part of the marsh. It is continuously covered with water except when the lagoon is dry or very nearly so Plants which cannot grow in deep water do not get a foothold here. Without question the dominating plant of this association is *Naias guadeloupensis*. It is found everywhere in the open water. and almost completely chokes the lagoon by the time it becomes half dried up. After that stage it is impossible to use a boat in the lagoon From December to May Pistia is exceedingly abundant, mostly floating around near the borders of this association, but when low water comes it seems to disappear. Lemna is also very common at times of high water, and a green alga becomes quite abundant as the lagoon is drying up. A list of the more important plants found in this environment follows:

1. *Naias guadeloupensis* (Spreng) Urban
2. *Pistia stratiotes* L.
3. *Ceratophyllum demersum* L.
4. *Castalia pulchella* (DC) Britton
5. *Castalia ampla* Salisb.
6. *Lemna perpusilla* Torr.

The plants of this zone are important in the ecology of bird life by supplying forage for the grebes, some of the ducks, the Porto Rican Coot and the Porto Rican Gallinule. In fact, almost the entire food of the Coot and Gallinule consists of the stems and leaves of Naias. These plants also supply food indirectly by harboring the larvæ of many aquatic insects which are eaten in considerable numbers by many of the marsh-inhabiting birds.

No birds are restricted to this environment in their nesting, but the species which occasionally nest here are the Pied-billed Grebe and the Black Necked Stilt, the latter species only nesting here when driven from its normal breeding ground.

II. THE CAT-TAIL ASSOCIATION

This association is very distinct, and contains but one species of plant (*Typha angustifolia L.*) There is almost no mingling with other societies. Wherever cat-tails are found in the lagoon, no plants intervene between them and the open water. In fact, cat-tails occupy many of the deepest parts of the lagoon. The probable explanation is that they cannot thrive in other spots at times of low water They grow much taller than any plants of the same species I have seen in temperate regions, those in the deeper parts of the lagoon attaining a height of from eighteen to twenty feet. The country people cut them in large quantities at times of low water and use them for roofing their huts, where they are said to last four or five years. The native name for plant is *Hinea* (*enea*).

Birds which nest in this environment almost exclusively are the Least Grebe, Least Bittern and Purple Gallinule. Others which commonly nest here, but are by no means restricted to this environment are the Porto Rican Coot, Porto Rican Gallinule, Allen's Ruddy Duck, Pied-billed Grebe, Porto Rican Zenaida Dove, Porto Rican Grackle and Porto Rican Golden Warbler.

The cat-tails offer no forage except the insects which they shelter. Their leaves and seeds are much used in nest construction.

III. THE SEDGE ASSOCIATION

This association follows the cat-tail association wherever present, and where absent borders on the open water association. It could more properly be called the Persicaria association, as these plants are more abundant than the sedges, but the dividing line between the Persicarias and the grasses is not so distinct as that between the sedges and the grasses. Persicaria is probably the most abundant plant at the lagoon. The first three species listed below are the dominating plants in this association:

1. *Persicaria portoricensis* (Bert.) Small
2. *Cyperus giganteus* (Vahl).
3. *Eleocharis interstincta* (Vahl) R and S.
4. *Cyperus articulatus* L.
5. *Sphenoclea zeylanisa* Gaerten. (On the south shore only)

This is the preferred breeding ground of the Pied-billed Grebe, Allen's Ruddy Duck, Porto Rican Gallinule and Porto Rican Coot, and probably of the Yellow-bellied Rail. Black necked Stilts also breed quite commonly here, though reaching their optimum in the grass association.

The seeds of Persicaria are important food items for many species of water and shore birds. Otherwise this association furnishes little forage, except for insects, which abound in its shelter.

IV GRASS ASSOCIATION

This association is very extensive at the east or shallow end of the lagoon, and there marks the transition from the marsh proper to the marsh border. At the deeper end it is of very small extent, and is soon followed by the Pluckea association. The grass association is characterized by grasses and by *Sesban emerus* (a leguminous herbaceous shrub). The following are the characteristic plants of this zone:

1. *Panicum geminatum* Forsk.
2. *Hymenachne amplexicaulis* (Rudge) Nees
3. *Sesban emerus* (Aubl.)

The seeds of *Hymenachne amplexicaulis* have the annoying faculty of digging their way into the flesh when one comes in contact with them while wet, and producing a strong stinging sensation. When these seeds are ripe, principally in September, wading in the grassy area is anything but a pleasure.

In this society most of the Black-necked Stilts nest. The Porto Rican Coot and Porto Rican Gallinule often nest here, and sometimes the Bahama Duck and Allen's Ruddy Duck.

This association is also much used as a feeding ground, especially by ducks, herons and certain shorebirds. Many seeds and insects are obtained here. A species of weevil, (*Tyloderma sp.*), which attacks Sesban is very frequently eaten by many species of birds.

V. PLUCKEA ASSOCIATION

This society forms the transition zone from the marsh proper to the border at the deeper west end of the lagoon. At times of high water there are about two feet of water in this area, but for about half the year it is high and dry, so that dry land forms which are resistant to a large amount of water form a dense mat of vegetation here The most characteristic plants are as follows:

1. *Pluckea purpurascens* (Sn) DC.
2. *Jussiaea repans* L.
3. *Asclepias curassavica* L Red Milweed or Bloodflower; Algodoncillo.
4. *Nymphoides humboldtianus* (HBK) Kuntze. Water Snowflake.
5. *Verbesiva alba* L.
6. *Cuscuta indecora* Choisy. Dodder.

Very few birds nest in this habitat, the only nests I have found here being of an occasional Porto Rican Gallinule and Coot, and one of a Porto Rican Golden Warbler. It is used more as a feeding ground, as a varied assortment of seeds and insects can be found here. During the winter it is the almost exclusive haunt of the Sora Rails.

VI. OPEN FIELDS ASSOCIATION

On the north and west sides of the lagoon the grass and Pluckea associations respectively merge into the open-fields association. This is a region of level fields on the floor of the extinct river valley, mostly planted to sugar-cane. The water for irrigating the cane is pumped from the lagoon. Extensive areas immediately bordering the lagoon are left uncultivated, largely because they are overflowed occasionally at times of extremely high water. Here *Lippia repans* and the grass *Chloris paraguaiensis* are the dominating plants. An occasional Porto Rican Royal Palm breaks the monotony of the fields. The principal plants found here are:

1. *Lippia repans* HBK.
2. *Chloris paraguaiensis* Steud.
3. *Panicum barbinode* Trin. Malojillo.
4. *Roystonea borinqueña* Cook.

This is the nesting ground of the Porto Rican Grasshopper Sparrow and the Antillean Killdeer, and where the taller *Panicum* grows, of the Bahama Duck, though most of them nest at a greater distance from the lagoon. It is also used extensively as a feeding ground for many species of birds, especially when the fields have been newly plowed.

VII. TACHUELO ASSOCIATION

At the shallow east end of the lagoon the grass association ends in a grove of yellow-flowered leguminous Tachuelo trees. This grove is about one acre in extent, and is a practically pure stand of Tachuelo [*Pictetia aculeata* (Vall) Urban]. The branches of many of them are densely covered with the epithyte *Tillandsia polystacyra* L. In these trees Jamaican Mockingbirds, Porto Rican Grackles, Anis, and an occasional West Indian Green Heron nest. It is not used as a foraging ground as much as one might expect, probably because the variety of seeds and insects offered is not great.

VIII. VARRONIA ASSOCIATION

On the south side of the lagoon, where the land rises quite abruptly from the marsh, there is only a narrow strip of the grass association, and this is followed by the Varronia association. This society is formed mainly of drought-resisting shrubs, with here and there a few herbaceous plants or a taller tree. By far the commonest shrub is *Varronia angustifolia*. The dominant plants found here are:

1. *Varronia angustifolia* West.
2. *Ricinella ricinella* (L) Britton.
3. *Lantana camara* L. (Red Sage. Yellow sage).
4. *Guazuma ulmifolia* Lam. (West India Elm).
5. *Spondias mombin* L. (Jobo).
6. *Bucida buceras* L.
7. *Solanum torvum* L. (*Wild Eggplant*. Berenjena Cimarrona).
8. *Bromelia pinguin* L. (Maya).
9. *Momordica zeylanica*
10. *Abrus abrus* (L) W. F. Wight. (Wild Licorice. Crabs' Eyes. Peronillas).
11. *Neptunia plena* L. (?)
12. *Peiranisia polyphylla Britton* and Rose. Retama prieta.

This is the principal breeding ground of the Porto Rican Ground Dove, Ani, Gray Kingbird, Yellow-shouldered Blackbird, Porto Rican Grackle, Carib Grassquit, Byrant's Grassquit, Jamaican Vireo and Jamaican Mockingbird. It is also a rich foraging ground, for seeds and insects are abundant.

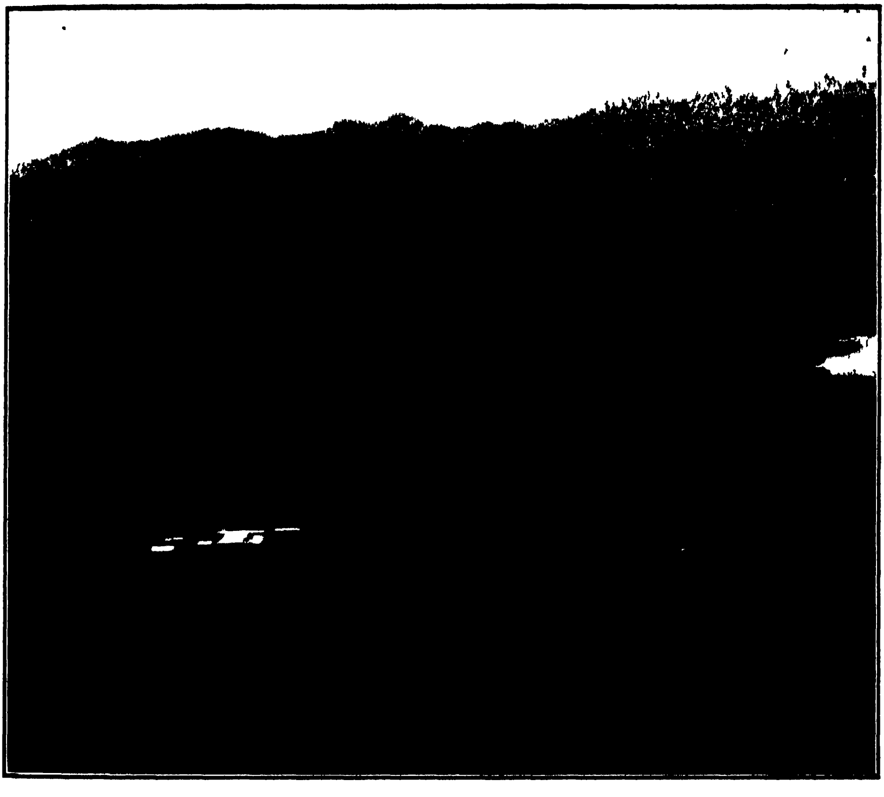

FIG. 3.—Bamboo Association (to left) and lower end of Cartagena Lagoon

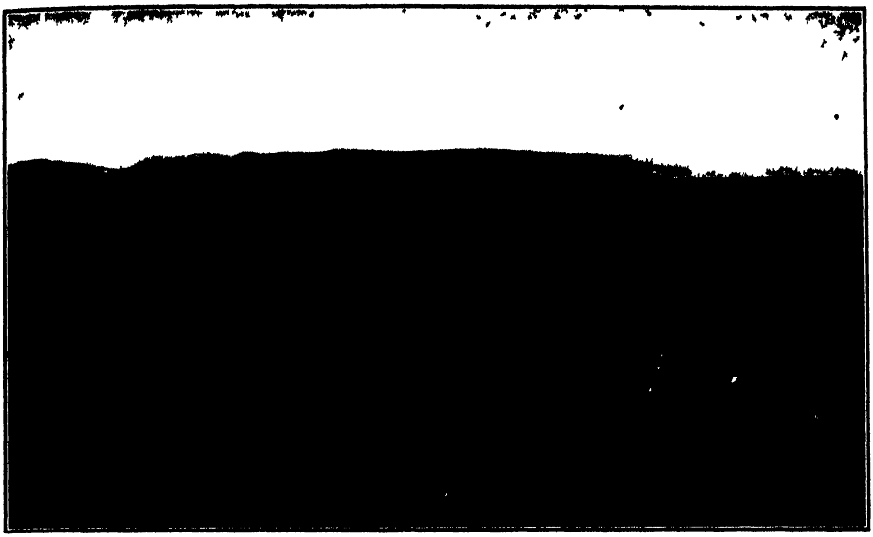

FIG. 4.—Guánica Lagoon, October 3, 1924

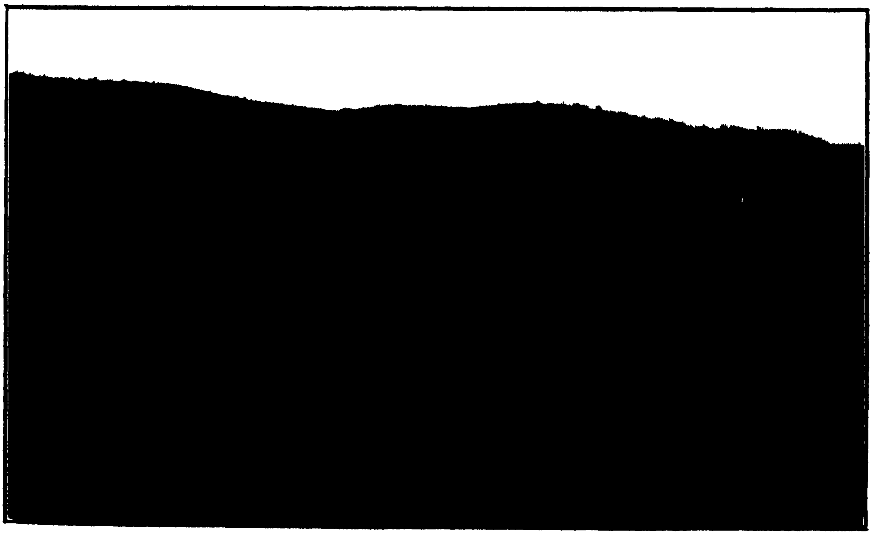

FIG. 5.—Guánica Lagoon, October 3, 1924

IX. BAMBOO ASSOCIATION

Although this association does not strictly speaking belong to the lagoon, it is necessary to consider it in an ecological study of the lagoon. It consists of the vegetation fringing the steep banks of La Quebrada, one of the tributaries of the Boquerón River which passes within a few hundred feet of the lower end of the lagoon, though not connected with it except at times of very high water. At such times it occasionally overflows its banks and some of its waters flow into the lagoon. On the other hand, when the lagoon is exceptionally full some of its surplus water spills into La Quebrada, and is carried through the Boquerón River to the sea. Like most of the streams in this part of the country, La Quebrada is nothing but a dry stream bed most of the time, but after heavy showers its volume is so great that it cuts a deep valley. Bamboos have been planted to help retain the walls of this valley and to prevent the stream from washing away the adjacent cane fields. A few other trees and a few herbaceous plants have sprung up among the bamboos, forming a dense but narrow strip of vegetation on each bank. Some of the principal plants found in this association are:

1. *Bambusa vulgaris* L. Bamboo. Bambú.
2. *Cordia nitida* (Vahl). Cerezo.
3. *Spondias mombin.* L. Jobo.
4. *Mangifera indica* L. Mango.
5. *Andiva ineuris* HBK.
6. *Cissus sicyoides* L.

Many of the lagoon birds come here to breed, and others include this association in their feeding range. It is the principal breeding ground of the West Indian Green Heron and of the Ani. Others which nest here are the Gray Kingbird, Jamaican Mockingbird, Porto Rican Golden Warbler, Jamaican Vireo and Porto Rican Honey Creeper. Little Blue Herons, Water-thrushes, Spotted Sandpipers and Porto Rican Ground Doves feed here extensively. This is the best place in the vicinity of the lagoon for migrant warbles. It is of especial importance to the bird-life of the lagoon because it is the nearest dense shelter available.

SUCCESSION

Conditions in the marsh are far from static. When I returned to the marsh in November, 1923, after an absence of nearly a year and a half I was impressed with the fact that the cat-tail area was much smaller than it had been. On more careful scrutiny other changes could likewise be noted. In most places sedges were replacing cat-tails and grasses were replacing sedges, and at the west end of the marsh the plants of the Pluckea association were encroaching upon the cat-tails. All were tending to fill in the marsh. But the regularity of this succession is not so great as would be expected in a northern cat-tail marsh. This is largely due to the periodical drying up of the lagoon, which gives some of the marsh border plants a chance to obtain a foothold in the marsh at times of low water. For example, some grasses straggle out into the open-water association, and in all the associations there is a greater intermingling of types than one would expect in a marsh where conditions were more uniform. During my absence the very shape of the lagoon had been changed. Very likely at this writing it has changed a good deal since I mapped it in the summer of 1924. Many years of observation are necessary for a detailed understanding of the succession. The accompanying map was made to aid in following these changes from year to year.

ANIMALS OF THE LAGOON

MAMMALS

Mammals are few in species at the lagoon as in the entire Island. There are no indigenous terrestrial mammals living in Porta Rico to-day, the mammalian fauna being limited to marine forms and bats, together with a few introduced terrestrial mammals.

The following mammals have been recorded from Cartagena Lagoon:

1. *Nyctinomus murinus* Gray. Furry-winged Free-tailed Bat. Three specimens of this bat were collected in an old house near the lagoon on September 27, 1924. Only two species of bats have been collected near the lagoon, but probably others occur at times. Both of them are insectivorous.

2. *Molassus fortis* Miller. Smooth-winged Free-tailed Bat. One specimen was collected August 20, 1924, and four on September 27, 1924, in old houses near the lagoon, from whence they issue at night to feed over the lagoon. Among those collected on the latter date was a young one which had attained nearly half adult size, but it had no teeth or fur as yet.

3. *Herpestes birmanicus* Thomas. Mongoose. The Mongoose is an introduced species which has become exceedingly common over the entire Island of Porto Rico. It has practically exterminated

snakes, which used to be very common in Porto Rico, and has also been making great reductions in the number of ground lizards and ground-nesting birds. It is very common at the lagoons, and is one of the worst enemies of the birds. It hunts over any region where the water is not deep enough to necessitate actual swimming, and thus occurs in all the plant associations except the open water association, and very often even there at times of very low water. It makes way with many eggs and young of such birds as the Gallinule and Coot, and probably with the adults of smaller species. I have seen one glide up behind an adult West Indian Green Heron and make a spring at it, but the heron realized its danger just in time to take hasty flight to safety. The Mongoose should be exterminated wherever possible. Although it was introduced to exterminate rats, rats are just as abundant as they ever were, but the same cannot be said of the native ground-nesting birds and lizards. Mongooses can be easily trapped in large wire-cage rat traps baited with fish heads. A boy in Mayagüez trapped twenty in this manner in about a month. They will also come freely if hen's eggs are used as bait, though they seem to prefer fish.

4. *Rattus rattus alexandrini Geoffroy.* Roof Rat. This introduced species is abundant in Porto Rico. It frequently occurs in and near the swamps, in all the plant associations except the Open Water and Cat-tail. It is more abundant in the canefields where it feeds upon the cane, but on coming to the marshes it often varies its diet with a few eggs and young birds.

5. *Rattus norvegicus Erxleben.* House Rat. This is another introduced species, less common than the preceding, and far less frequently seen in the marsh. Otherwise the habits of the two species appear to be quite similar. Most of the trapped animals I have observed in Porto Rico have been Roof Rats.

6. *Mus musculus musculus* Linnaeus. House Mouse. Introduced and abundant in Porto Rico. Often found in the grass and sedge associations in the lagoon at times of low water, where it apparently feeds upon seeds.

I believe it is possible that a second species of mouse may occur, though none such has been listed from Porto Rico. On two occasions near the lagoon I observed a mouse with a very red back, once in a canefield near the lagoon, and once in a growth of Persicarias in the sedge association, but neither time was I able to collect the specimen seen, so that it cannot yet be recorded.

REPTILES

1. *Anolis cristatellus* (Duméril and Bibron). Common in the Varronia and open field associations, and occasionally penetrating into the grass and sedge associations of the lagoon proper, where it feeds upon insects. Numerous specimens were collected.

2. *Anolis stratulus* (Cope). Common in the Varronia and Open Field associations.

3. *Anolis pulchellus* (Duméril and Bibron). Common in the Open Fields association, and frequently enters the grass association of the lagoon proper. On September 27, 1924, many were stranded on isolated plants and hummocks in the newly flooded part, thus falling easy prey to birds, some species of which, notably the Porto Rican Grackle (*Holoquiscalus niger brachypterus*), are very fond of them.

4. *Anolis poncensis* (Stejneger). Lizards of this species were noted at the base of Tinaja Hill, directly south of the lagoon, and probably occur at times in the Varronia Association. All the Anoles are insectivorous. Being small and lacking means of defense they are included in the bill of fare of many birds.

5. *Ameiva exsul* (Cope). Frequently noted and twice collected in the Varronia association. These lizards are too large to be fed upon extensively by most birds except birds of prey, though small specimens are occasionally taken by other birds, such as the Gray Kingbird.

6. *Ameiva wetmorei* (Stejneger). Though I have not found this recently discovered species in the immediate vicinity of the lagoon, it occurs not uncommonly on Tinaja Hill, where I collected three speciments on May 6, 1924. It is conspicuous with its yellow lateral stripes and brilliant green tail, and prefers the arid limestone hills.

AMPHIBIANS

1. *Leptodactylus albilabris* (Günther). This is the only amphibian recorded from the lagoon. Its tadpoles abound in the grassy parts of the lagoon during November and December, and later many small frogs occur in the same region. I have never observed an adult at the lagoon, though I have collected a number of them at Mayagüez. The tadpoles and small frogs form an important element in the food of the lagoon birds, particularly of the herons.

FISHES

Fishes are very few in species at the lagoon. I have personally observed only three species, but have been told of a fourth which is very rarely found and of a fifth which was said to occur in the lagoon before it dried up for the first time. The identity of this species I have not been able to ascertain. It was known to the country people as *Pez grande,* and is said to have lived in the mud and to have attained a weight of as much as twenty pounds. When the lagoon dried in 1923 all of them were cleaned out, and none have appeared since then. The following four species exist at present in the lagoon:

1. *Anguilla chrysypa* (Rofinesque). Eel. Anguilla. Eels are very abundant in the lagoon though seldom seen except when it is drying up. During the drying-up period in June and July most of the attentions of the eggers are diverted from egg hunting to eel fishing. The eels are obtained with fish spears of from one to four, usually two, prongs known as *figas,* or more often with *machetes.* The boys and men wade around up to their knees or even to their waists in mud, brandishing their machetes which they let fall on any luckless eel they encounter, usually nearly severing the head with the force of the blow. On July 5, 1924, I counted seventy large eels which twelve boys had secured, and they were still killing others rapidly. Some were over forty inches in length, and most of them were from twenty-five to thirty-five inches long. The eels appear to be of little ecological significance. I have no records of their being eaten by any birds, but having observed a Great Blue Heron eating an eel in the north I would not be surprised if its southern relative occasionally eats an eel.

2 *Centropomus parallelus* (Poey). Robalo. This fish is reported by the country people living near the lagoon, but I have never observed it there, and do not feel very certain of its identity.

3. *Awaous taiasica* (Lichtenstein). Mapiro. This is a rather scarce fish at the lagoon, usually seen swimming among the cat-tails. I have observed it on only a few occasions. It is said by the country people to bury itself in the mud at times of low water.

4. *Poecilia vivipara* (Bloch and Schneider). Cisi. This is by far the most abundant fish at the lagoon, occurring everywhere that the water is deep enough to permit of swimming. They swarm in great numbers in the shallower places. It is the only species which enters into the food of the birds to any great extent. This little fish is mut-eating and viviparous. Nearly half of those captured

were males. This is a larger proportion than is usual among viviparous fish.

INSECTS

Space permits mention to be made of only a few of the dominant insects of the lagoon. Dragonflies and damseflies of many species abound. They and their naiads form a considerable proportion of the food of the aquatic birds. Bloodworms (Chironomidæ) abound in the mud, and when the water is low in the lagoon they form the greater part of the food of the small shore birds which then visit the lagoon in almost countless numbers. Mosquitœs are rarely seen in the daytime, though abundant enough at night. Most of them apparently breed in the nearby salt water, as both adults and larvæ are seen much more abundantly there. Aquatic Coleoptera (Dytiscidæ and Hydrophilidæ), are abundant, and they and their larvæ are important food items of the birds. Aquatic Hemiptera, especially Naucoridæ (*Pelocoris femoratus*), are extremely abundant, and large Belostomidæ are not at all uncommon. Pelocoris forms the favorite bill of fare of several species of birds. Its nymphs are known as "*cucarachas de agua*" (water cockroaches), and they are extremely obnoxious from their habit of stinging people who venture bare-footed into the lagoon. Their sting is about as painful as that of wasp, but the pain soon disappears. Unfortunately these are not the only small aquatic creatures that cause painful stings, for an almost microscopic Entomostracan, locally known as "*agua viva*" (living water), also has this disagreeable habit. Their sting is not so painful as that of the *cucaracha de agua*, but they make up in numbers for what they lack in quality.

In the drier parts of the lagoon and in the fields surrounding it are found a great variety of terrestrial insects. Porto Rico is noted for its great variety and abundance of cockroaches, thirty-seven species having been described up to 1923, and new species are constantly being discovered. Many of these occur near the lagoon, and form a considerable item in the food of the birds. Grasshoppers are common, but not especially abundant. The Porto Rican Mole Cricket .or *changa* (*Scapteriscus didactylus*), abounds in the cane-fields surrounding the lagoon. It is considered by entomologists and by the public to be one of the worst insect pests of the Island. Fortunately several species of birds are very fond of them, particularly the Ani (*Crotophaga ani*), and the West Indian Green Heron (*Butorides virescens maculatus*). Every possible protection should be given these birds.

Coleoptera occur in great profusion, as in most tropical regions, Fleabeetles are particularly numerous. Among the worst beetle pests found near the lagoon are white grubs (larvæ of *Phyllophaga vandinei*), and the Sugar Cane Stalk Weevil (*Diaprepes spengleri*). Coleoptera form the largest part of the food of the insectivorous birds, and the most injurious species form a goodly proportion.

The insects which are most conspicuous as one approaches the lagoon are the clouds of butterflies which arise as one walks through the fields. About nine per cent of them are of one species, (*Anartia jatrophæ Linnaeus*). Their black, spiny larvæ feed on *Lippia reptans*) (HBK), which forms a large part of the Open Fields association. On September 23, 1924, these larvæ were so excessively abundant as to nearly conceal the plants. Some other species of butterflies which are often found with *Anartia jatrophæ* are *Junonia genoveva* (Cramer); *Didinis biblis* (Fabricius); *Anosia plexippus* (Linnæus); *Euptoieta hegesia* (Cramer); *Callidryas eubule* (Linnæus) and two undetermined species of *Lycæna.*

The most prominent and most feared species of Hymenoptera is the Bembecid *Stictia signata* (Linnæus). They are constantly flying over the lagoon, especially over the Persicarias, often chasing flies. They live in holes in the ground near the edge of the lagoon. When one sits down to eat lunch two or three of them are sure to come buzzing around appearing very formidable and ferocious. Although they have a prominent sting, I have not learned of an authentic case cf a person being stung by one. I have no records of this species being eaten by birds.

A small ant (*Prenolepis sp*), is very abundant, and nests in the large tops of the Giant Sedge (*Cyperus giganteus Vahl*), during the time that these are in blossom and seed, or from September to December. During the balance of the year these ants are often found breeding in the nests of Coots, Gallinules and other marsh birds.

White ants (*Isoptera*), of several species are very abundant, but are seldom eaten by birds as they remain in places inaccessible to them except when flights of the winged form take place. On such occasions birds eat many of them.

CRUSTACEA

Three species of land crabs live near the borders of the lagoon. Dr. Mary J. Rathbun, of the U. S. National Museum, kindly identified these for me. The common large blue land crab is *Cardisoma guanhumi* (Latreille). It lives in large tunnels in the ground which it excavates for itself when the ground is soft after the rains, leaving big heaps of mud near the entrance. They rarely emerge from these holes during prolonged droughts. They are largely carnivorous in their habits, and are an enemy to the birds to some extent. I have observed an especially large crab of this species taking eggs from under a hen which was incubating in a nest in a box near the ground not far from a marsh. It pushed the hen half way off the nest and proceeded to devour the eggs. The hen was powerless to prevent it. Doubtless these crabs often rob the nests of ground-nesting birds Another crab which is found much more rarely near the lagoon is the smaller blue-bodied, pink-legged *Gecarcinus ruricola* (Linn.), a form which is peculiar in that the eggs hatch directly into crabs with the form of the adult. A male of this species which I sent to the U. S. National Museum is the first specimen they have of this species from Porto Rico. Another crab which is not often found at the lagoon though it is abundant on the nearby limestone hills is *Coenobita clypeatus* (Herbst). They live in large, heavy snail shells, but despite the cumbersome weight of these shells they can travel quite rapidly They are practically omnivorous Near Cabo Rojo Lighthouse I have seen them so abundant that in a patch of about ten square feet they were packed so closely that it was impossible to see the ground, and thousands of others were nearby on all sides When one stopped to eat lunch these crabs gathered by the hundred from all sides to try to get their share of it. They would eat anything that was thrown to them, from meat scraps to orange peels. It was difficult to keep them out of our food supplies when camping, as they would tear through heavy pasteboard boxes to get at the food inside. They were particularly active at night, though by no means inactive in the daytime. Small birds' nests would not be safe where they are abundant, as they are not only found on the ground, but they climb to some extent. I once found a small specimen climbing up a cat-tail stem in the lagoon.

DOMESTIC ANIMALS

Cattle are pastured in the fields surrounding the lagoon, and they often wade in the marsh proper to graze upon the succulent grasses and other plants which grow there. Pigs and goats also run at large through the marsh where it is not too deep, while domestic turkeys, guineafowl and hens feed along the shore.

FIG. 6—Pumphouse, Cartagena Lagoon

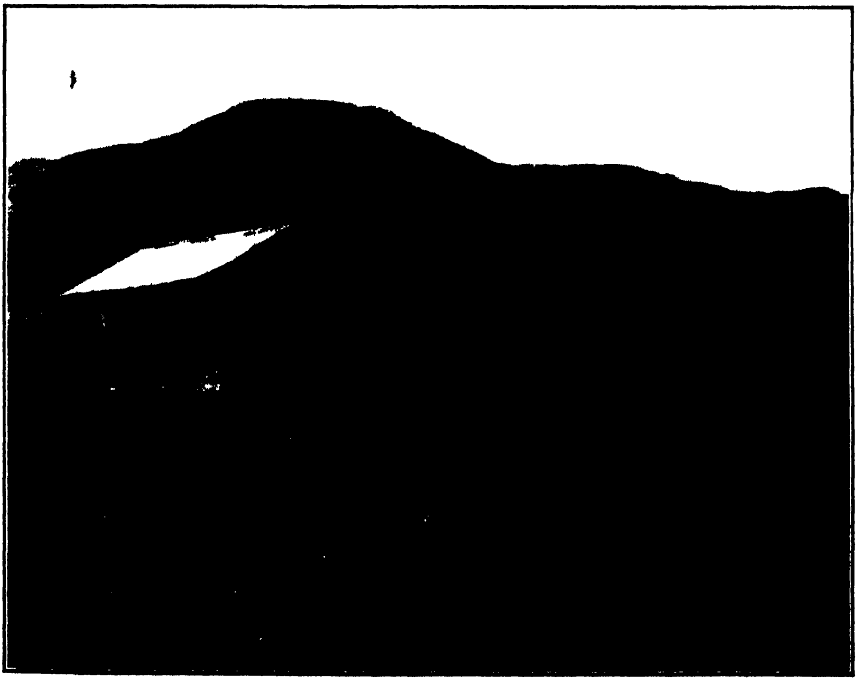

FIG. 7.—Boathouse, Cartagena Lagoon

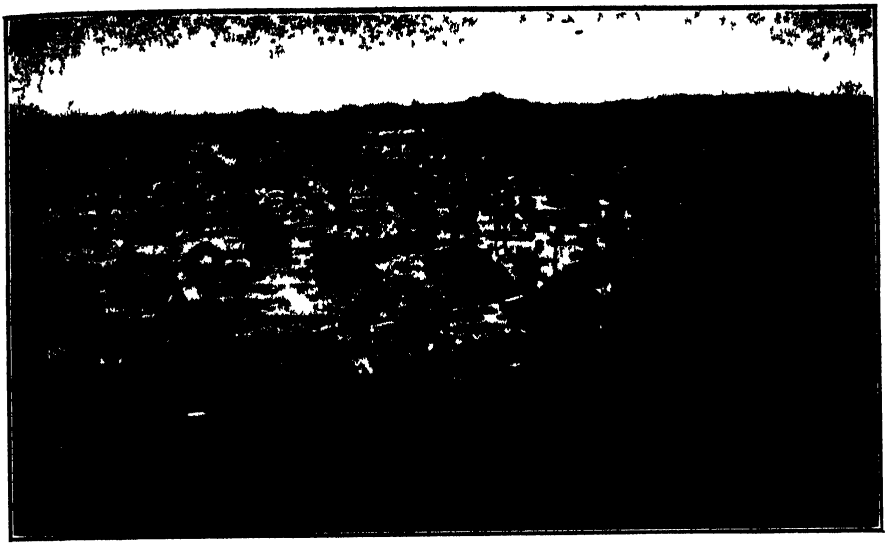

FIG 8.—Cartagena Lagoon Open Water Association with Pond Lilies April, 1922

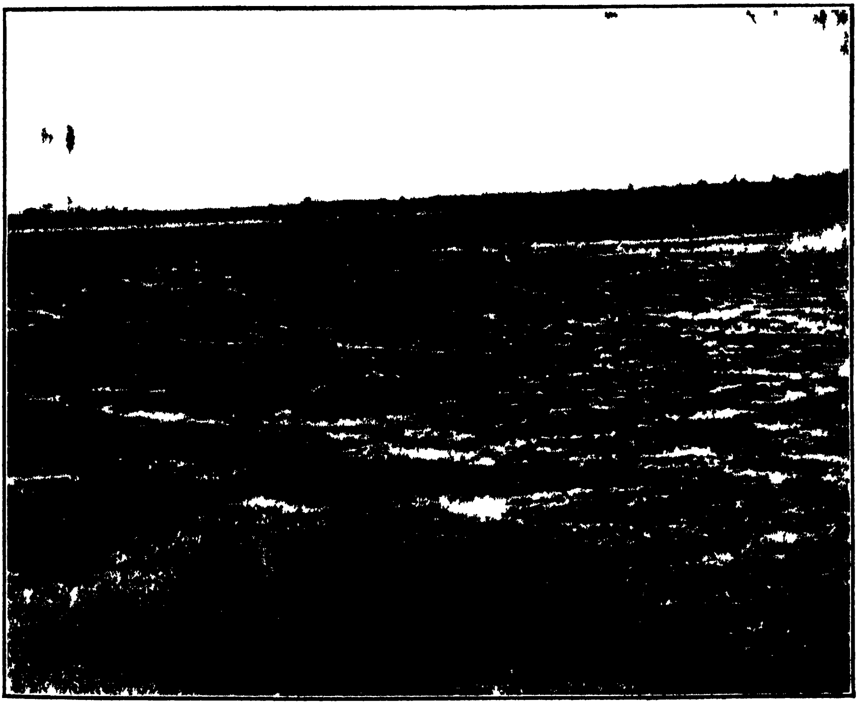

FIG. 9.—Cartagena Lagoon. Open Water Association with Pied-billed Grebe Nest in Foreground. May, 1924

WORKING CONDITIONS AT CARTAGENA LAGOON

The difficulties of ornithological work at Cartagena Lagoon were so great that at times it seemed very discouraging. In the first place it was necessary for me to live at Mayagüez, and there was just one train a day from there to the lagoon. It allowed me only six hours a day at the lagoon, and I had to spend four on the train going back and forth over the twenty-six intervening miles of rail. Occasional outbreaks of fever kept me from making as frequent visits to the lagoon as I would have liked.

At the lagoon the eggers interfered greatly with my work. They searched the marshes so systematically that I was able to follow any given nest through to the hatching period in but one or two cases. Unfortunately the eggers did not confine their attention to the edible eggs of the larger species, but with incomprehensible lack of foresight they destroyed all eggs too heavily incubated to be eaten, "so as to save the next man the trouble of examining them". They did not seem to realize that by so doing they were "killing the goose that laid the golden egg". And this is not all. Any small birds' eggs which they found were broken and thrown away. Once I asked an egger why he did it. He answered: "I dont know; I just can't bear the sight of an unbroken egg remaining in a nest, no matter what kind it is". It seems marvellous to me that any birds are left in a region where such destruction is permitted.[1] Of course the actions of the eggers prevented the doing of much intensive work on nesting habits. I actually had to pay the boy who carried some of my photographic and other equipment extra in order to prevent him from taking the eggs in the nests I found and wished to photograph. It was impossible to use a blind for bird photography at the lagoon, for a blind would immediately attract attention to the nest upon which it was set, and by my next visit. the eggs, and like as not, the blind itself would have disappeared. The taking of eggs is a pernicious habit, and should by all means be prohibited by law and sentiment. If the birds and their eggs are not protected during the breeding season they have but small chance of reproducing their kind. The surest way to decrease the number of birds is to permit the taking of breeding birds and their eggs. The present laws prohibit this to some extent, but many revisions are necessary to adequately protect the birds. Cartagena Lagoon is the most important breeding ground for waterfowl on the Island, and it would well repay the Porto Rican people to have it regularly patrolled by an officer of the law, especially during the breeding season.

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[1] This destruction is not permitted It is done in violation of the law An appendix has been prepared containing legislation enacted and in force —THE EDITOR

At certain times of the year Cartagena Lagoon is a favorite rendezvous for hunters from Mayagüez and Ponce, while the country people hunt at all times of the year, whenever they get money enough to buy ammunition. The hunters add to the difficulties of the ornithologist, not only by the number of birds they take and by the danger from passing shots, but by keeping the birds stirred up. Many a time when I have been concealed in the cat-tails or other vegetation trying to photograph or watch certain birds, a hunter's shot or one of the boys stationed around the marsh to keep the birds in flight has scared my birds away and thereby spoiled an afternoon's work.

That bloodthirsty villain the Mongoose ranks perhaps third as an arch enemy of the ornithologist, though it seldom molests nests placed among vegetation growing in deep water.

Stinging Entomostracans, *Cucarachas de agua* and stinging grass seeds produced much discomfort, but did not interfere seriously with work. Every country person and city hunter I have talked with who was familiar with the lagoon a few years ago tells me of the vast number of large leeches which formerly lived there and caused great discomfort if not actual serious injury to those persons who ventured into the lagoon. It is said that the leeches attained a length of eight inches, and that as many as thirty frequently attached themselves to a man within a few minutes. Somewhat similar conditions still exist in a small marsh near Cabo Rojo. But at Cartagena Lagoon the leeches were said to have all suddenly disappeared immediately after the hurricane of September, 1921, when the lagoon waters rose very high and the high wind whipped it into large waves. Possibly they were washed out to sea. At any rate none are now to be found, much to the relief of any one who has occasion to work in the marsh.

PART III

BIRDS OF CARTAGENA LAGOON

The species of birds discussed in the pages which follow include all those which are known to occur at Cartagena Lagoon. Under each species are given the scientific, English, and Spanish names used by the people who live near the lagoon; a statement of the occurrence of the species at the lagoon; an account of the habits; accounts of the nesting and young, of the enemies, of the food, and of the ecological and economic importance of the species. In many cases the Spanish names will be found to differ from those given in published accounts of Porto Rican birds. Most of these were given by Gundlach, who in many cases gave the names by which he had known the species in Cuba.

1. *COLYMBUS DOMINICUS DOMINICUS* (Linnaeus). Least Grebe. *Tigua.*

Least Grebes are common permanent residents at Cartagena Lagoon, leaving it only when the lagoon is so dry that they cannot swim. In 1924 they stayed until June 21, when there was very little water at the lagoon, and appeared again August 26, very soon after the first shower had begun to replenish the lagoon waters. About twenty-five pairs bred in 1924. Only about six pairs bred in 1922 when there was water at both Anegado and Guánica Lagoons.

The cat-tails are the favorite haunt of this little grebe, and it is seldom seen far from them. Even while feeding it seldom goes far away from their protection. Often after one has been standing still among the cat-tails for some time the gray form of a Tigua will pop up beside him, usually to disappear again as quickly as it had at first appeared. They are usually found in loose flocks at all times of the year, probably not so much from any gregarious instinct as from a community of interest which brings large numbers together where conditions are favorable. Flocks of as many as seventy-five are often seen at Cartagena Lagoon during the breeding season. Their favorite feeding ground is in patches of open water immediately adjacent to growths of cat-tails. The water in such places is usually so choked with Naias, and at other times so shallow that the Tiguas are seldom able to swim under water. At these times they take wing at the slightest alarm, and head directly for the cat-tails, so it is very difficult to observe them closely unless one hides behind a screen of cat-tails. When frightened they fly with a weak wing-stroke which enables them to keep their bodies barely above the surface of the water. They gain increased speed by pushing downwards and backwards against the water with their feet, though their body is supported entirely in the air. When deep water free of Naias is available (just after the lagoon has filled up) these little grebes have a chance to show off their far-famed powers of diving and swimming under water. They are then observed much less frequently as they dive at the slightest suggestion of danger, to reappear again only among the cat-tails. When they have been frightened away from their feeding ground they do not return to it for half an hour or over, even when the cause of their alarm does not remain in the vicinity.

The note of the Least Grebe is a loud, reed-like "week", but it is seldom uttered.

The Least Grebe is commoner than the Pied-billed Grebe. When on the water they are easily confused unless a close view is obtained, when the smaller size of the Least Grebe, and particularly its grayish coloration and light-colored iris can be noted. There is no danger of confusing the species when in flight, as the white in the wing of the Least Grebe is very conspicuous, making the wing appear almost white from a distance.

The Least Grebe, as I have already indicated, nests exclusively among the cat-tails, and usually in the deepest parts of the swamp, as that is where the rankest cat-tails grow and where the nests are freest from molestation. All the nests I have found were anchored to cat-tails in water from one to three feet deep, and were made of partially decayed cat-tail leaves, with occasionally a few rootlets in addition. These are heaped to-gether to form a bulky rounded mass mostly below the surface of the water. Those in shallow water were built up from the bottom, but those in deeper water were strictly floating affairs. They are slightly hollowed at the top to receive the eggs. Although this species is said to lay from three to six eggs in other parts of its range (Bent, 1919, p. 37), three eggs is the largest set I have found in Porto Rico, and often only one or two eggs are laid. However, Struthers (1923, p. 469), records nests with as many as seven eggs. The eggs are pure white when laid, but they soon become so stained with dirt that they become deep brown in color. A freshly laid set of two eggs observed on September 6, 1924, became quite dark in a week. Eggs nearly ready to hatch are very dark. I found that I could guess the stage of incubation rather closely by observing the color of the egg. In almost every case the adults covered the eggs with decayed vegetation before leaving the nest. The only time this was not done was in the case of very much stained eggs nearly ready to hatch.

The months in which these grebes nest most frequently are April and May, and September to November. Apparently they raise two broods a year.

On May 16, 1924, I obtained a young bird from pipped egg. The markings as noted on this were: The color is brownish black above. There is a large triangular rufous patch on the crown, and a narrow stripe of the same color extends forward from this patch to the base of the bill. On each side of this rufous patch is a short white stripes, and another white stripe extends from each eye backward onto the neck. The under side of the head is white, with two broad black stripes converging at the base of the bill. The back is brownish-black with two narrow white lines extending from the neck to the tail. The breast and belly are a dirty white. The bill is mostly creamy white, more or less dusky at the tip and on the upper surface of the upper mandible. On the lower mandible there is a narrow black V. The egg tooth is pure white.

The worst enemies of the Least Grebe are the native eggers and the so-called sportsmen who shoot any birds that come in sight whether they are fit to eat or not. However, this species suffers less than most of the aquatic birds from the former cause, as their nests are placed in some of the most inaccessible places that can be found at the lagoon. Unfortunately the birds are quite easy to shoot if the hunter hides in the cat-tails near their feeding grounds. This species is infested with tapeworms to a remarkable degree. Several tapeworms, often as long as 100 millimeters, were taken from each of the five adult specimens I collected.

Very little has been recorded about the food of the Least Grebe. Apparently the sole account in literature is an unsatisfactory note by Gosse (1847, p. 443): "The gizzards of all that I obtained were filled with a finely comminuted substance, rather dry, of an unctuous appearance, and mingled with short silky filaments. A close examination with a lens failed to determine its nature; but I believe it to have been principally vegetable."

Five stomachs from Cartagena Lagoon, taken in September and October, were obtained. The material in these was much comminuted and rather difficult to determine, but upon careful examination the greater part of the material was identified. Animal food comprised 99.8 per cent of the total. The only vegetable matter found was a few seeds of *Sesban emerus* in one stomach. Feathers comprised 35.4 per cent of the stomach contents, showing that this species has the feather-eating propensities so characteristic of the grebe family. The animal food was composed entirely of insects, mostly aquatic forms. Some of those found were dragonfly naiads, 6 per cent (eaten by two birds); adult dragonflies 1 per cent (eaten by one bird); adult damselflies 4 per cent (eaten by three birds); Naucoridae, *Pelocoris femoratus*, 8 per cent (eaten by two birds); adult Hydrophilids 1 per cent (eaten by two birds); Hydrophilid larvæ 3 per cent (eaten by two birds); aquatic Dipterous larvæ 1 per cent (eaten by one bird); two Maybeetles, *Phyllophaga vandinei*, and one Carabid beetle, comprising 1.5 per cent, were eaten by one bird, and are the only terrestrial forms found. Very likely they were specimens which had fallen in the water.

The Least Grebe is a strictly aquatic species, entirely dependent upon the marsh for food and shelter. It is incapable of long migratory flights on accounts of its short wings, so they wander little or not at all from their native marsh unless forced to by the drying up ot the waters of the marsh. It is so thoroughly adapted to an aquatic existence that it is doubtful if it could exist long elsewhere. It is primarily a bird of the cat-tail association, and seldom ventures far from its protection.

2. *PODILYMBUS PODICEPS ANTILLARUM* (Bangs). Antillean Pied billed Grebe. *Zaramago. Zaramagullón.*

The Pied-billed Grebe is a rather common permanent resident at Cartagena Lagoon, though slightly less common than the Least Grebe. It leaves only when the lagoon dries up so much that swimming is impossible. In 1924 it left June 21, and returned August 26, thus going and returning on identically the same days as the Least Grebes.

This grebe is more a bird of the open-water association than the Least Grebe, and seldom seeks the protection of the cat-tails, either for feeding or nesting. It escapes danger by diving if the water is deep enough or by swimming if it is not. It takes flight much more rarely than the Least Grebe. They are never seen in flocks; usually they occur singly, occasionally in pairs. They are less easy to observe from a cat-tail blind than the Least Grebe because they feed mostly far out in the center of the lagoon, and also because if once frightened from one part of the lagoon they seldom return to it in less than three or four hours. Four or five pairs breed at Cartagena Lagoon. The species is fully as common in summer as in winter, and I doubt very much if any migrants from North America occur, despite the prevalent belief that they do.

The call of the Antillean Pied-billed Grebe consists of a long series of cuckoo-like notes followed by some gulping sounds, thus: *cow, cow, cow, cow, cow, cow, cow, cow-wullup, cow-wullup.* The female also has a soft *cuk, cuk* note which she uses when calling to her young.

The larger size, browner coloration and black throat easily distinguish this bird from the Least Grebe. Birds in breeding plumage (with the black throat), may be seen at all times of the year. Immature birds lack the black throat. I do not have sufficient specimens to ascertain whether the adults ever acquire a winter plumage similar to that of North American birds or not.

On April 4, 1924, during a rather heavy shower, I observed the courtship and mating of this species. The male chased the object of his devotions at high speed for about two minutes, making a great splash in the water, and occasionally diving and coming up near the female. I did not observe any vocal sounds accompanying this performance, but the noise of the rain might have prevented that. Finally the male capture the female and mating took place.

The nests of the Pied-billed Grebe are found in the open-water association where the water is from two to three feet deep, either built up from the bottom in the open-water, or floating and anchored to a few cat-tails or grasses which straggle farther out towards the center of the lagoon than most of their kind. All the nests I have found were constructed of Naias. Sometimes this was quite fresh, in other cases it was largely decayed. The nest is a bulky structure built up about two inches above the surface of the water. The top is slightly hollowed to receive the eggs. In every case these numbered three at Cartagena Lagoon, though Struthers (1923, p. 469) records a nest with six at Anegado Lagoon. The eggs are white when laid, but soon become stained brown.

The breeding season is not so well marked as that of the Least Grebe. I have found young about one-third grown on December 7, 1923, and newly hatched young on December 11, 1923. Struthers (1923, p. 469) records a nest with eggs on February 18, 1922. On March 17, 1924, I found newly hatched young, but by far the greater part of the nests with eggs and young are found in April and May.

On April 30, 1924, I had the opportunity of observing a nest the day the young were hatching. One egg had just hatched, one was pipped and the third, as I learned later, was infertile. Before leaving the nest the parent covered the two eggs, leaving the new hatched young on the edge of the nest. When I approached the nest it dived into the water, but I caught it easily and replaced it in the nest, but it would not stay there long enough to be photographed. When I visited the nest on May 2 the mother grebe was seen swimming nearby with a bunch of pondweed and the two young on her back. The infertile egg remained uncovered in the nest. When the old bird wanted to get the young off her back she simply took a dive and apparently dumped them off.

The downy young is strikingly marked with black, white and rufous. The upper parts are mainly black. Two white superciliary stripes and two white stripes above them converge at the forehead. There is a small triangular-shaped rufous patch on the crown, and a rufous stripes runs from one eye around the back of the neck to the other eye, the rufous color becoming brighter in color on the back of the neck than it is near the eyes. Behind this, on the neck, is a short rufous bar. The back is black, with six narrow white stripes running its entire length. The underparts are dull white, with a little black mottling on the under sides of the head and neck. The bill is mainly black, with a brownish-red fleshy area at the base. The egg tooth is large and is pure white in color.

The worst enemies of the Pied-billed Grebe are the eggers. Hunters account for some losses in the rank of this species, but they are much harder to shoot than Least Grebes and so are obtained much less frequently.

The stomachs of two Pied-bills from the lagoon were available for examination. That of an adult collected April 18, 1924, contained 4 dragonfly naiads (8 per cent) and fragments of many Naucoridæ, *Pelocoris femoratus* (8 per cent), in addition to the customary feathers found in all grebes' stomachs, which in this case formed 80 per cent of the stomach contents. The stomach of a downy young, not over three days old, collected March 17, 1924, contained but one feather, but that was large and formed 10 per cent of the stomach contents. In addition to this the stomach contained 1 Mole Cricket, (*Scapteriscus didactylus*), forming 86 per cent. Vegetable matter constituted 4 per cent, and consisted of two small pieces of Naias, 1 seed of *Hymenachne amplexicaulis* and a little rubbish. A stomach from Aguadilla examined by Bowdish and one from Manatí by Wetmore contained crawfish.

FIG. 9 *a*.—Cartagena Lagoon. Cat-tail Association in Background. June, 1924

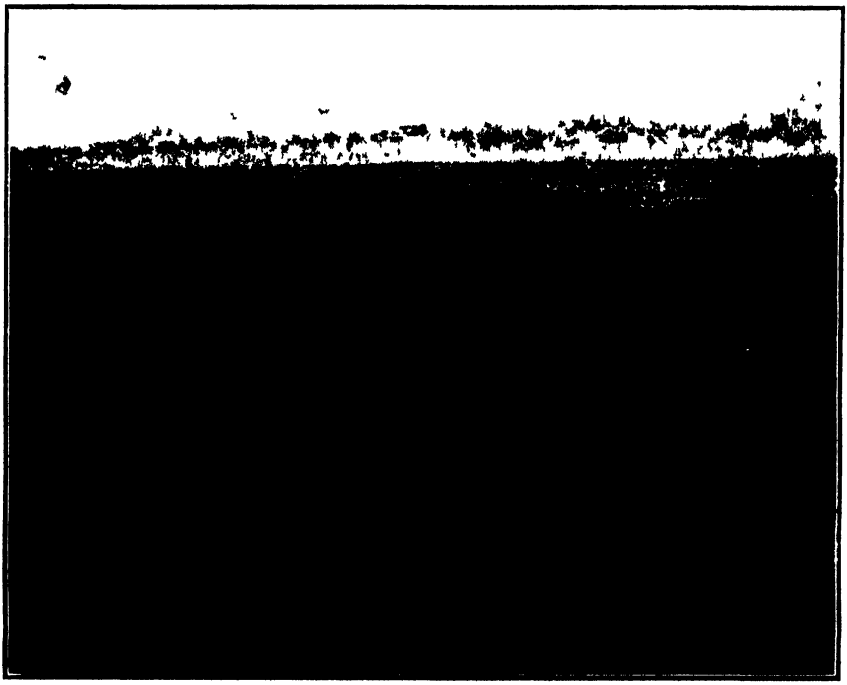

FIG. 10.—Cartagena Lagoon. Grass Association. May, 1924

FIG. 11.—Cartagena Lagoon. Grass Association, Tachuelos in Background

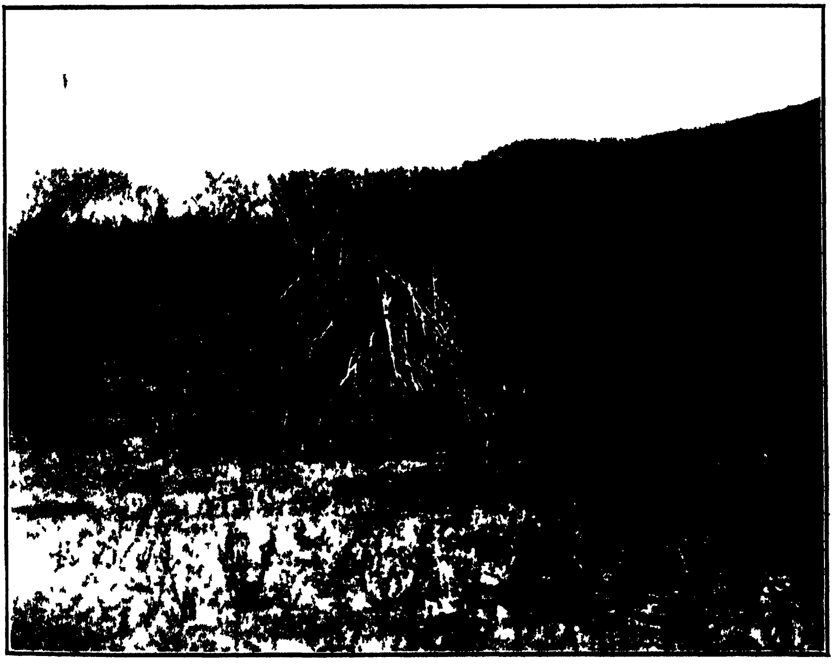

FIG. 12—Cartagena Lagoon. Sedge Clump (Eleocharis) in Foreground, Cat-Tails in Background

The Pied-billed Grebe is a strictly aquatic species, and dependent entirely upon the marsh for food and shelter. The scanty data available on its food habits indicate that it is a useful bird and worthy of protection. It is a bird of the open-water association and is seldom found in the cat-tails. In this respect it differs materially from the Least Grebe in its habits.

3. *LARUS ATRICILLA ATRICILLA* (Linnaeus). West Indian Laughing Gull. *Gaviota.*

Laughing Gulls occur commonly on the coasts of Porto Rico, but are very rarely seen at the fresh water lagoons. I have observed this species on two occasions at Cartagena Lagoon, two birds seen on May 27, 1924, and one on September 3, 1924. Apparently Laughing Gulls do not nest on the main island, and it is doubtful if they nest on Desecheo Island, but nevertheless they are seen on both islands in spring and summer months only. In 1922 my first record for the arrival of this species at Mayagüez was March 10; in 1924 it was March 6. They are not seen after September.

4. *GELOCHELIDON NILOTICA* (Gmelin). Gull-billed Tern. *Gaviota.*

The Gull-billed Tern is a summer resident at Cartagena Lagoon, though it does not breed. Its occurrence in Porto Rico was previously unknown. In 1924 they arrived on May 20, and stayed until September 3, staying right through the period when the lagoon was dry, as they could obtain a plentiful supply of insects from the mudflats. They were almost constantly on the wing, and obtained their food by swooping down to the mudflats and scooping in the insects without stopping their flight. Occasionally they could be seen in small groups resting on the mudflats. Even while there were still little pools of water these terns picked their food from the partly caked mudflats rather than from the water.

On July 9, 1924, I collected a female from a flock of nine resting on the mudflats. The ovary was somewhat enlarged, the largest ovules being three millimeters in diameter. The stomach of this bird contained 58 aquatic Hemiptera (*Pelocoris femoratus*), constituting 94 per cent of the contents. One dragonfly naiad formed 4 per cent, and 1 *Corixa reticulata* 2 per cent.

The Gull-billed Tern evidently finds conditions quite favorable for its existence in the mudflats of a drying lagoon, else it would not remain there all summer so far from its normal breeding range.

5. *THALASSEUS SANDVICENSIS ACUFLAVIDA* (Cabot). Cabot's Tern. *Gaviota.*

Cabot's Tern is an irregular winter visitor to Cartagena Lagoon. An individual in winter plumage was observed skimming over the lagoon on each of my trips between December 4 and December 22, 1923. Nothing has been recorded of the food habits of this species in Porto Rico, where it is by no means common, even on the coast.

6 *HYDROCHELIDON NIGRA SURINAMENSIS* (Gmelin). Black Tern. *Gaviota prieta. Gaviota ceniza. Pitirre de agua.*

The Black Tern is a common fall migrant at Cartagena Lagoon. It is never found there in the spring, but it is said by the country people to occur every year in large numbers in September. In 1924 the first birds arrived on August 20, and none were noted after October 7. From 150 to 175 could be noted almost any day in September In 1921 Struthers (1923, p. 474) noted twenty on August 18.

The flight of the Black Tern is very erratic and swallow-like, making them difficult marks for the hunter. When one is shot and injured its comrades gather around above it and make a great din of sharp cries. Occasionally large numbers of terns could be seen perched on the wire fence which crosses the lagoon or on the mudflats, but when resting they are very wary and it is impossible to approach within gunshot of them. They often hover low over the surface of the water while feeding. They obtain most of their food from the open-water regions, but scattering groups forage over the dry grassy fields at some distance from the lagoon. On one occasion I observed a Black Tern catching dragon flies on the wing over the water. During the latter part of their stay at the lagoon these birds began to act peculiarly. On September 27, 1924, a closely packed flock of sixty were flying back and forth over the lagoon, wheeling around, dipping to the water and rising again, always in perfect unison, each bird maintaning its respective position in the flock. This occurrence was noted again on September 30, 1924, only this time the flock numbered seventy-six. After this date only about twenty-five scattering birds were observed. The only call note observed from any of the birds was a sharp metallic *peek.* It is from this note that the native name of *Pitirre de agua* is probably derived, as it is somewhat suggestive of the call note of the Pitirre (*Tyrannus dominicensis*).

When the Black Terns arrive most of them are either in the light winter plumage, though quite a number in the dark summer plumage or in a pied intermediate plumage can be observed. As the season progresses the number of black and pied individuals decreases until in October all the birds are in the light plumage. On September 3 approximately one hundred and fifty Black Terns were observed. Of these 130 were in light plumage, 10 were dark and 10 were pied. On September 20, two out of 125 were dark, and five were pied. After September 27 no dark birds were observed.

While in Porto Rico the worst enemy of the Black Tern is the sportsman. It is a favorite mark of his, as it tests his skill in shooting more than most common birds. Some of the better marksmen bag large numbers of terns.

The stomachs of three birds collected on September 3, 1924, contained 99.7 per cent of animal matter and 0.3 per cent of vegetable matter. Hydrophilid larvæ composed 55.3 per cent of the total. One bird had eaten 119 of them and another 36. Noctuid moths comprised 33.3 per cent. One bird had eaten nothing but five large moths. Other insects found were an ambush bug (2.3 per cent); a damselfly (2 per cent); a dragonfly (3.8 per cent) and a Lamellicorn beetle (1 per cent). The only vegetable matter found consisted of one *Hymenachne* seed and a little rubbish, in one stomach.

Although the Black Tern does not obtain all of its food in the marsh, it is primarily a bird of the marsh and more particularly of the open water association. It show a preference for aquatic insects, though not spurning terrestrial forms. It is less strictly aquatic than most of its allies, and it is my belief that it may represent a branch of the family gradually diverging towards a more terrestrial existence.

7. *PHALOCROCORAX VIGUA MEXICANUS* (Brandt). Mexican Cormorant.

On October 17, 1924, I observed a small cormorant. flying over the cat-tails at Cartagena Lagoon. It continued its flight over the lagoon and far away over the mountains to the north without once stopping. Unfortunately I was unable to collect it, but I feel very confident that it was of this species. No cormorants had previously been recorded from the Island. A native boy who was assisting me and who knew the local birds very well gasped in amazement when he saw this bird and said he had never seen one like it before.

8. *FREGATA AQUILA* (Linnaeus). Man-o-war Bird. *Rabijunco.*

The Man-o-war Bird is a salt-water species which rather frequently but irregularly visits Cartagena Lagoon in search of food. I have recorded them at the lagoon in every month except February. Usually they come singly, but on two occasions (December 11, 1923, and July 5, 1924) I saw three soaring together. Generally they soar overhead at a considerable height, but occasionally they dip down to the surface of the water, making a splash when they hit it, but only their bills go under water. Probably they are catching small fish, as Dr. Wetmore found the food of this species to consist entirely of fish. Any Coots that chanced to be near when the Man-o-war Birds made these dives flew away in terror

There is a nesting colony of Man-o-war Birds on a small coastal island near Parguera, about five miles from Cratagena Lagoon, and probably most of the birds that visit the lagoon are occasional visitors from this colony.

9. *MARECA AMERICANA* (Gmelin). Baldpate. *Pato Lablanco.*

The Baldpate is a rare winter visitor to Cartagena Lagoon. I observed a flock of ten on February 27, 1924, and again on March 1, and on March 11 a male and famale at close range. They were feeding in the open-water at the eastern end of the lagoon where the grasses straggle some distance out into it. No specimens were collected, so I can make no definite statements concerning their food, though I believe it does not differ greatly from that of the Blue-winged Teal which prefers the same part of the lagoon.

10. *QUERQUEDULA DISCORS* (Linnaeus). Blue-winged Teal. *Pato oelecal.*

The Blue-winged Teal is a common winter visitor at Cartagena Lagoon. In 1924 the last birds in the spring were seen on May 2, and the first fall migrants appeared on September 6. They do not become common until November or December, and in the spring they are not common after about the tenth of April. They prefer the shallower parts of the lagoon, and are about as often found paddling about in the sedge and grass associations as in the open water. They are even found quite frequently among the cat-tails. A moderate estimate of the number of Teal wintering at the lagoon in 1923 and in 1924 would be 500 each year. This species is also very common at the other lagoons when they contain water. On March 4, 1922, I counted over 1,000 at Anegado Lagoon. They are very wild and difficult to shoot, so a comparatively small toll of their numbers is taken by hunters. If the existing game laws were strictly enforced this species would be adequately protected.

Only one stomach, that of a female collected April 11, 1924, was available for examination. This contained 99 per cent of vegetable matter and 1 per cent of mineral matter. 90 per cent of the vegetable matter consisted of 83 seeds of *Persicaria portoricensis.* The rest was rubbish. The mineral matter consisted of three small pebbles.

11. *SPATULA CLYPEATA* (Linnaeus). Shoveler. *Pato cuchareta.*

The Shoveler is a very scarce winter visitor. The only certain record I have is that of a crippled female observed at Cartagena Lagoon on May 30, 1924. She was in a dense growth of sedges. She could fly only a few feet before dropping clumsily into the sedges. On two other occasions I made rather unsatisfactory identifications of this species. On February 27, 1924, I saw a few ducks that I took to be this species at Cartagena Lagoon, and on April 1, 1922, at Anegado Lagoon I observed two ducks that appeared to be Shovelers, but in neither case could I approach closely enough to be positive of the identification.

12. *DAFILA ACUTA TZITIHOA* (Vieillot). Pintail. *Pato pescuecilargo.*

The Pintail is an uncommon winter visitor at Cartagena Lagoon. The first certain record of the occurrence of this species in Porto Rico was a male bird which I observed at close range at the lagoon on April 8, 1922. This record is included by Bent in his Life Histories of North American Wildfowl (1923, p. 155). In 1924 I observed a flock of six on February 15; a flock of seven and another of three on February 27, and a pair on March 11. They were feeding in the grass association at the east end of the lagoon. At that time the water was so deep that they could easily swim among the grasses. The flock of six observed on February 15 was accompanied by a seventh duck which was probably an albinistis bird of some stockier species. The wings, breast and under side of the throat of this bird were pure white, while the top of the head was dark brown and the back black.

18. *POECILONETTA BAHAMENSIS BAHAMENSIS* (Linnaeus). Bahama Duck. *Pato Inglés.*

The Bahama Duck is a common permanent resident at Cartagena Lagoon, leaving only when it becomes so dry that swimming becomes impossible. In 1924 they disappeared on June 18, to reappear on August 20. About 125 was the largest number observed in one day at the lagoon.

The grassy region is the favorite feeding ground of the Bahama Duck at times of high water, though it is not at all averse to feeding in the sedges, and is often seen feeding in the open-water association. On a few occasions I have flushed Bahama Ducks in the Pluckea association. The shallow grassy region at the east end of the lagoon is the region where one is surest of finding them. They usually feed in pairs or small flocks of from three to ten individuals, though occasionally flocks of as many as eighty are seen. They do not associate closely with other species Often they are forced to scatter out while feeding among the Coots, Gallinules and other ducks. especially among the Blue-winged Teal, but upon taking flight they always form flocks of their own. The Bahama Ducks are very silent birds. On only two occasions have I heard them under utter any notes. Both times when I was near young birds hidden in the sedges. The first time was December 11, 1923. The female then made a circle around me, making a continuous low quacking sound as it flew, scarcely audible at a greater distance than 100 feet. The second occasion was October 11, 1924. This time the female flew in eleven clockwise circles around me, and then two counter clockwise circles After that her flight became quite erratic, but she made occasional lunges toward me. All this time she was absolutely silent except for a single low quack which she emitted when quite close to me.

The Bahama Duck very seldom nests at Cartagena Lagoon. I have never had the opportunity of examining a nest, but reliable natives have often described them to me. They say that these ducks always nest in dry grassy fields at some distance from the water, and that they then lead their young to water. Certain it is that though the nests are never found at the lagoon, parents with young unable to fly are frequently encountered. A native of the lagoon region by the name of Eladio Sanoguel, whom I found to be a very accurate observer, described to me on May 20 a nest that he had found the day before. He said it was on the ground in a field of Guinea Grass at a distance of one kilometer from the lagoon. It contained twelve eggs the color of which he described as a light hen's egg brown. A city hunter claimed the eggs and took them home to try to hatch them under a hen. Apparently the breeding season is quite extensive, as I have encountered young unable to fly on October 7, 11 and 17, 1924, and on December 11, 1923, and Struthers (1923, p. 471) records a nest with twelve eggs at Anegado Lagoon on February 18, 1922, and young unable to fly on December 8, 1921. On August 30, 1924, I observed several Bahama Ducks flying low over grassy fields at some distance from the lagoon. The country people said they were then building nests. From this evidence it would seem that the breeding season extends more or less continuously from February to November. The young scatter and hide or dive at the slightest warning, so it is seldom possible to obtain a good view of them.

Among the enemies of the Bahama Duck the Mongoose probably ranks high, as with other ground nesting birds. Then there are the egg hunters who take the eggs to eat, and last but not least are the hunters who consider the Bahama Duck an especial prize.

The stomach of a male Bahama Duck collected April 11, 1924, contained 6 per cent of animal matter and 94 per cent of vegetable matter. The animal matter consisted of 2 Dytiscid larvæ. Ninety per cent of the vegetable matter was pondweed (*Naias guadeloupensis*) and the other 10 per cent consisted of 20 seeds of *Persicaria portoricensis*. In addition mineral matter to the extent of 52 per cent of the stomach contents was found. This consisted of coarse gravel, 85 per cent of which was red rock and 15 per cent white quartz. Dr. Wetmore examined the stomachs of eight adults, which contained green algae (83.75 per cent) and seeds of ditch grass (*Ruppia maritima*) (16.25 per cent), while two downy young had eaten various grass seeds varied with a few aquatic Hemiptera.

The Bahama Duck is dependent upon the marsh for food but not for shelter. It breeds away from the marsh, but is found there at all other times. Apparently it has found that its nests are safer in other places. If it nested in the marshes at present it is doubtful if many nests would escape the ravages of the eggers. It appeared to be less common in 1924 than in 1922. It needs absolute protection from February 1 to December 1 to keep it from becoming a *rara avis* in the Porto Rican avifauna.

14. *MARILA AFFINIS* (Eyton). Lesser Scaup Duck. *Pato turco.*

The Lesser Scaup Duck is a winter visitor to Cartagena Lagoon. In 1924 the last birds seen in the spring were two on May 16, and the first fall arrivals noted were a flock of twelve (six males and females), on September 23. On May 5, 1924, I observed a flock between fifteen and twenty in migration, at Mayagüez. It was ju before sunset. They were flying due north over the ridge of hill which separates Mayagüez and Añasco valleys. They kept in A formation, and flew at a height of about 200 feet above the hill At Cartagena Lagoon the Lesser Scaup is common in February an March, but occurs rather sparingly earlier and later. As many a 200 may be observed in one day in February. I noted them a common at Anegado Lagoon on March 4, 1922. On January 5, 1924 there were about 50 at Guayabal Reservoir in the mountains nea Villalba.

At Cartagena Lagoon the Lesser Scaup inhabits the open-water association exclusively. It is almost always found in small flocks of from two to twelve. On two occasions I have observed flocks of greater size, a flock of forty on March 11, 1924, and one of sixty on March 17, 1924.

While in Porto Rico man is the worst enemy of the Lesser Scaup, as they keep well out towards the center of the lagoon, out of reach of the marauding Mongoose. They also succeed fairly well as a general rule in keeping out of reach of hunters, most of whom try for game that is more easily obtained, and the flesh of which is more palatable.

In the three stomachs examined, animal matter constituted 50.5 per cent and vegetable matter 49.5 per cent. All the animal matter was contained in one stomach, and consisted of 13 Planorbis snails (80 per cent of animal matter), and 6 Belostomidæ (20 per cent of animal matter). 73 per cent of the vegetable matter consisted of pondweed (*Naias guadeloupensis*); 6.7 per cent of seeds of Compositæ; 20 per cent of *Persicaria portoricensis* seeds; and 0.3 per cent of seeds of *Hymenachne amplexicaulis*. In addition, gravel to the extent of 39.7 per cent of the stomach contents was sound. A bird collected by Dr. Wetmore (1916, p. 29) at Guánica Lagoon had eaten mostly insects, including aquatic Hemiptera, Coleoptera and dragonfly naiads.

While at Cartagena Lagoon the Lesser Scaup is strictly a bird of the open-water association; it is harmless in its food habits, and quite well able to take care of itself under existing game laws. Its flesh is not particularly palatable, though it is better in the fall than in the spring.

FIG. 13—Cartagena Lagoon. Pluckea Association. Cat-tails in Background

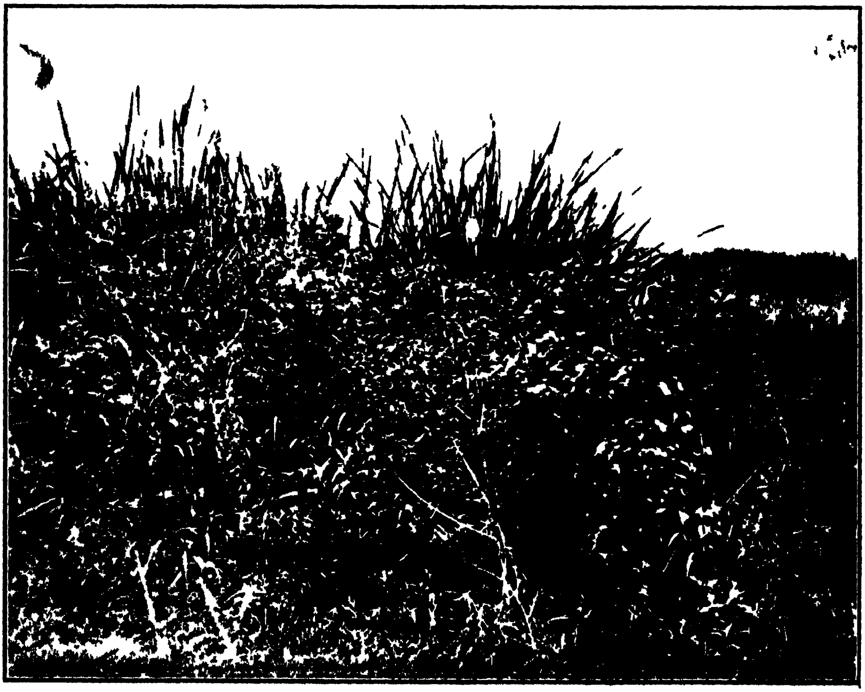

FIG. 14.—Cartagena Lagoon. Pluckea Association. Cat-tails in Background

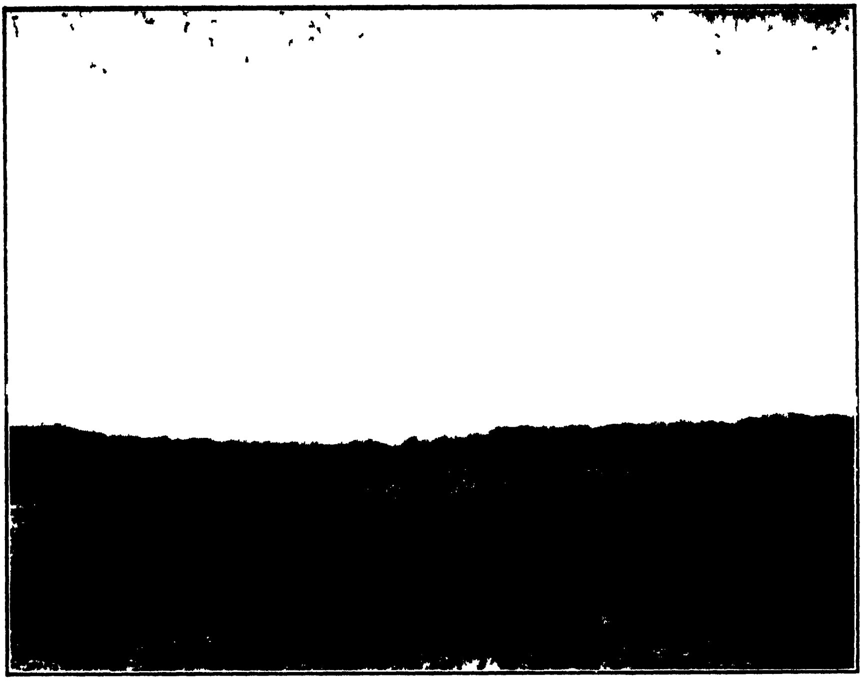

FIG 15—Cartagena Lagoon Mudflats in July

FIG. 16.—Porto Rican Royal Palms

15. *ERISMATURA ALLENI* (Danforth). Allen's Ruddy Duck. *Choriso. Pato chorizo.*

Allen's Ruddy Duck is a common permanent resident at Cartagena Lagoon, and is one of the commonest breeding birds there. However, as in the case of other aquatic birds, it is forced to leave when the lagoon becomes dry. In 1924 the last one seen as the lagoon was drying up was on June 14, with the exception of some molting birds unable to fly observed on June 28. They began to return on August 20, but it was September 3 before they were back in their usual numbers. Most of them apparently go to the mangrove swamps of the coast when forced away from the lagoon. As nearly as I can estimate somewhat over 100 pairs nested at Cartagena Lagoon in 1924. When Anegado and Guánica Lagoons are dry as many as 300 birds at a time may be observed feeding at Cartagena. A few were noted at Guayabal Reservoir on January 5, 1924.

Allen's Ruddy Duck feeds primarily in the open water and cat-tail associations, and nests in the cat-tail and sedge associations, and to some extent in the grass association.

One of the most characteristic and attractive sights at the lagoon is a raft of these dapper little ducks in the more open parts with a dense growth of tall cat-tails rising like a wall behind them. On the appearance of danger they often swim into the cat-tails for protection, but they more often take wing and fly to some distant part of the lagoon. On first appearance it would seem that their almost absurdly short wings would be unsuited for flight, but such is decidedly not the case, for they are often seen flying over the lagoon, especilly on days when they are much disturbed by hunters. When a gun is fired near them they almost invariably try to escape by taking wing instead of by swimming or diving. But unless one comes upon them suddenly or startles them by firing a gun they usually swim slowly away from one, keeping a little over a gunshot ahead until they meet some obstruction, when they invariably fly. Their flight is rapid and almost bullet-like, usually for but short distances, and is maintained by very rapid wingbeats.

Allen's Ruddy Ducks usually live in flocks of from ten to a hundred, occasionally as many as two hundred. While feeding the individuals scatter somewhat and are usually associated with Coots or with Lesser Scaup Ducks, and when flushed they likewise fly with the Coots and Scaups, though remaining somewhat segregated. On extra windy days the ducks stay out in water that is rough enough to drive the Coots to shelter.

Although primarily birds of the open-water association Allen's Ruddy Ducks frequently feed among the cat-tails, and are very often found in the parts of the open water near them. This is probably because most of the deepest parts of the lagoon are near the cat-tails. This fact is well known to the hunters, who conceal themselves in the cat-tails and obtain large numbers. It is one of the first species to approach a blind after the hunter conceals himself.

These little ducks obtain most of their food by diving when the water is deep enough to make this necessary, but they do not stay under water long.

This species has been previously considered identical with *E. jamaicensis* of North America, but upon examination of the specimens collected the wing and tail proved much shorter, the tarsus longer and the coloration darker than *E jamaicensis.* These characteristics, together with the fact that the male undergoes no eclipse plumage, as such, influenced me in describing the Ruddy Duck found in Porto Rico as a new species.* Male birds of this species may be observed in the red plumage every month in the year, and molting birds in March were molting from red into red. This constitutes a deep and fundamental difference between *E. alleni* and *E. jamaicensis,* the males of which spend at least half the year in the brown eclipse plumage, in which they closely resemble the female.

The Ruddy Ducks are extraordinarily silent birds. I cannot recall hearing them utter call notes of any kind Shortly before the nesting season they may be observed swimming around in pairs among the cat-tails and sedges, apparently investigating suitable nesting spots, but I have never observed the actual mating.

The nesting season apparently extends from November to May. Gundlach (1878, p. 407) found them hatching at Guánica Lagoon in November 1873. Struthers (1923, p. 471) records twenty-two nests found at Anegado Lagoon from December 1, 1921, to March 1, 1922. At Cartagena Lagoon I have found nests from December to May, and the birds were apparently getting ready to breed in October 1924. The eggs were just hatching in a nest found on December 27, 1923. The latest nest I have found was one in which the complement of six eggs was completed on May 23, 1924. This nest was broken up before the eggs hatched. Another nest that had one egg on this date was also broken up. By far the greater number of nests I found were from the latter part of February to the early part of May, but March is the month in which nests are found most abundantly and in which the eggers live highest.

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* Described in the October 1925 *Auk* as *Erismatura alleni*, named in honor of Dr. Arthur A Allen, Professor of Ornithology at Cornell University

Several types of nests are used, but perhaps the commonest is made of sedge and grass stems and placed in clumps of sedges where the water is a foot or less in depth. It is a rather bulky affair, built up so that the bottom of the nests is about at water level, yet it is well concealed in the sedge clumps. The top is hollowed to receive the eggs, but it is not much more than deep enough to contain them. On Las Casitas many nests are built among the tall grasses where there is little or no water. These nests are constructed almost exclusively of grasses. I have found four floating nests of this species anchored among the cat-tails. They were built of dead cat-tail leaves, built up to such a height that the bottoms of the eggs rested about four inches above the surface of the water. They were all in the edges of the cat-tail areas, and anchored in water from eight inches to four feet deep. One of these was found on December 27, 1923; one on February 19, 1924, and two on May 9, 1924. Another nest was found May 23, 1924, in the cat-tails where the water was only four inches deep, so that it rested upon the bottom.

The nests which appeared to contain full complements of eggs contained from four to eight eggs. The average is six or seven. However, Struthers (1923, p. 471) records finding nests with from one to twelve eggs at Anegado Lagoon, and Mr. Luis H. Mendoza, a university graduate and an experienced hunter, informs me that at a small marsh at Cabo Rojo he once found a nest with twenty-two eggs. It is possible however that in the case of some of the larger sets more than one female deposited eggs in the same nest. The eggs are very large for the size of the bird. They are white in color. The smallest egg measured was 62 × 48 millimeters, the largest 65 × 50 millimeters. It was impossible to make long-continued observations of any of the nests found, due to the activities of eggers and the marauding Mongoose. In one case, however, a nest remained undisturbed long enough for me to ascertain the rate of deposition of eggs. On May 16, 1924, I found a new nest of grass, placed among the cat-tails on what was then dry land, as the lagoon had already receded to a considerable extent. On that date it contained one egg. On the 20th it contained four eggs, and on the 23rd, six eggs. On the 27th all the eggs had disappeared. Thus the female laid an egg nearly every day until the set was completed.

The young on hatching are covered with a rather stiff, bristly down. It is blackish brown above, with a whitish spot on each side of the back. A brownish-white stripe runs from the bill below the eye to the occiput. Beneath this is a much broader brownish-white stripe, extending onto the chin. The rate of the underparts are grayish white, shading into dark brown on the throat.

Very few of the eggs laid are destined to ever become adult ducks, for their enemies are many. First and foremost among these are eggers. The eggs are large and of good flavor, and are consequently most eagerly sought after. On March 1, 1924, five eggers collected nearly 200 eggs of this species. The eggers comb the marshes with great regularity, and the wonder is that any eggs are left to hatch. The adult birds constitute one of the largest items in the hunters' bags, as they are easily obtained by shooting from the cat-tails. The Mongoose likewise looks upon Allen's Ruddy Duck eggs with particular favor, and many a broken up nest gives telltale evidence of this culprit. But this species is confronted with a peculiar danger in addition to those already enumerated. In common with all other ducks this species has the habit of molting all its primaries at once, rendering it flightless for a period. Many of them are at this flightless stage when the lagoon dries up. They flounder around on the mudflats and fall an easy prey to hunters, who use dogs to aid in their capture. On June 28, 1924, many were being caught in this manner.

The stomach contents of five birds collected on March 1, 1924, were examined. Four other specimens were collected for me later, but unfortunately their stomachs were not saved. Animal matter comprised 9.8 per cent of the stomach contents, and vegetable matter 90.2 per cent. Of the animal matter, 47 per cent was dragonfly naiads; 20 per cent Dytiscid larvæ, and 33 per cent Belostomidæ. Of the vegetable matter, 68 per cent was seeds of *Persicaria portoricensis;* 28.7 per cent pondweed, (*Naias guadeloupensis*); 2.5 per cent seeds of Compositæ; 0.4 per cent seeds *Sesban emerus* and 0.4 per cent rubbish. Mineral matter, which formed 59.2 per cent of the stomach contents, consisted of coarse gravel. Eighty per cent of this was red shale, and 20 per cent white quartz.

To sum up, Allen's Ruddy Duck feeds primarily in the open water society, where it associates with the Porto Rican Coot and Lesser Scaup Duck. It breeds in the cat-tail and sedge associations, and, on the island, in the grass association. It is entirely dependent on the marsh for its food, and is harmless in its food habits. It is a very important game bird in a land where game birds are few, and to preserve it much better protection from its principal enemies (eggers, hunters and the Mongoose) is imperative. The taking of eggs should be absolutely forbidden. The game laws at present permit the hunting of this bird from January 1 to May 1, which is entirely within its breeding season, during which it should receive absolute protection. An open season during the fall months would be much more satisfactory.

16. *DENDROCYGNA AUTUMNALIS* (Linnaeus) Black-bellied Tree Duck. *Chiriría.*

The Black-billied Tree Duck is not uncommon at Cartagena Lagoon, especially during the autumm months. Often while walking through the tall sedges a seemingly enormous bird is flushed and with a few shrill whistles sails over the marsh to take refuge in some distant part of it. If a native son of Porto Rico be present the word *Chiriría* will instantly be upon his lips and a longing look will come in his eyes as he watches a dinner fit for kings speedily departing from him. The Chiriría is sometimes found in the grasses and cat-tails as well as in the sedges. It is seminocturnal, and feeds mostly by night. According to the country people, most of the Chiririas spend the day in the hills and descend to the swamp at dusk to feed. Hunters lie in wait along their lines of flight and obtain them at that time, and a royal good meal they are said to make. The birds seen in the day time are always flushed singly or in pairs; at night they are said to come in flocks of as many as twenty-five. Eladio Sanoguel reported 100 feeding at Cartagena Lagoon by night on October 10, 1924, and I have frequently been told by various hunters of the occurrence of from 50 to 75 individuals. Unfortunately I was unable to visit the lagoon by night to observe their feeding habits at first hand, but they are said to feed not only in the marsh, but in cultivated fields as well, especially those in which grain is grown.

The Black-bellied Three Ducks nests rarely, if at all, at Cartagena Lagoon. The only evidence I have of its ever nesting there was the discovery of a very large rotten white egg, at least twice as large as that of a Ruddy Duck, found floating among some cat-tails on May 30, 1924. People who live near the lagoon say that the Chiriría nests on Tinaja Hill, building nests of grass on the ground in bushy places, and that they lay from eight to fourteen eggs. Eladio

Sanoguel reported finding such a nest with one egg on September 6, 1924, but the press of other work prevented me from investigating it. He says that soon after hatching the parents lead the young to the swamps. Struthers (1923 p. 471) records finding a nest with two eggs and two nestlings in a hollow tree at Anegado Lagoon on February 18, 1922. Gundlach (1878 p. 400) says they nest on growths of Bromeliaceæ, on large horizontal limbs of trees, in hollow trunks, and in the dense vegetation of the lagoons, that the nest is made of dry leaves and twigs, and that twelve to fourteen or more eggs are laid.

Probably hunters and the Mongoose are the worst enemies of this species. It is apparently much scarcer than it used to be in Gundlach's time. I know nothing definitely about its food habits, but I have heard no reports of damage done in recent years to crops. Its rank as the largest and most palatable Porto Rican game bird certainly entitles it to protection, at least from March to November.

17. *DENDROCYGNA ARBOREA ?* (Linnaeus). Tree Duck. *Chiriría pinta.*

A second species of tree duck occurs in Porto Rico, and is found rarely at Cartagena Lagoon. The native hunters are familiar with it, but they say it is very rare. Mr. Luis H. Mendoza saw a flock of eight on February 24, 1924, and described them as being a little larger than the ordinary *D. autumnalis,* and as lacking the white color in the wing. He said the general coloration as seen from above was reddish brown. His description agrees substantially with that commonly given by the hunters. On October 17, 1924, I saw a tree duck in the distance which lacked white in the wing, and which I was told was this second species. I did not see it well enough to positively identify it as *Dendrocygna arborea,* but I believe it was this species.

18. *BOTAURUS LENTIGINOSUS* (Montagu). Bittern. *Yaboa.*

The Bittern is a casual migrant to Porto Rico and to Cartagena Lagoon. I flushed one from a dense growth of sedges on November 30, 1923. There are only three other published records for the Island. One was observed by Gundlach (1878, p. 361) at Guánica Lagoon in November 1873, and he records (1874, p. 313) one in the collection of Blanco at San Juan. Struthers (1923, p. 471) took a specimen September 23, 1921, in a swamp near Boquerón.

19. *IXOBRYCHUS EXILIS EXILIS* (Gmelin). Least Bittern. *Martinete chico.*

The Least Bittern is a fairly common permanent resident and breeder at Cartagena Lagoon, though much commoner in the winter and spring than in the summer and fall. It is primarily a bird of the cat-tail association, though it feeds quite extensively in the sedge association, and to same extent in the grass association. When disturbed while feeding away from the cat-tails it invariably flies with dangling feet and alights in them for protection. When one alights on a dead cat-tail it is difficult to distinguish the bird from the leaf, as the bird is so long and slim and protectively colored.

The Least Bittern places its nest in the cat-tails four or five feet above the water. The nests are almost flat platforms, but quite substantially built of cat-tail leaves, sometimes with the addition of pieces of Persicaria plants. I have found nests from April 11, 1924, to May 9, 1924. From two to three pale bluish-white eggs are laid; two fresh eggs were collected from a nest on May 9, 1924. They measured 1.30 × 0.95 inches. On May 2, 1924, I observed two adults accompanied by three young scarcely able to fly. Struthers (1923 p. 471) records a nest with eggs at Guánica Lagoon on April 2, 1921, and Gundlach (1878, p. 360) found a nest on the branch of a shrub with three eggs on May 7, on the bank of the Arecibo River.

The Least Bittern is a very retiring bird, and apparently is not much disturbed by the Mongoose or by hunters. Eggers take their eggs whenever found, and are probably the worst enemy of the species.

No stomachs were obtained for examination, but Wetmore (1916, p. 27) reports that small fish formed 84.34 per cent of the contents of three stomachs collected at Guánica Lagoon on may 26. Crustacean remains formed 13.33 per cent; amphibian remains 0.33 per cent and aquatic Hemiptera 2 per cent. Many feathers were also eaten by these birds.

The Least Bittern is thus shown to be strictly a bird of the marsh, nesting and seeking shelter in the cat-tails, but feeding largely in the grass and sedge associations. It is a harmless or even slightly beneficial species. The taking of its eggs should be prohibited.

20. *ARDEA HERODIAS ADOXA* (Oberholser). West Indian Great Blue Heron. *Garzón cenizo. Yaguasa.*

The West Indian Great Blue Heron is a tolerably common permanent resident. It ocurs at Cartagena Lagoon at all times of the year, but does not nest there. Its case is probably analagous with that of most of the other herons, which feed at the lagoon but resort to the mangroves of the coastal islands for nesting. Apparently this is a species which has been increasing slightly recently. In 1911 and 1912 Wetmore (1916, p. 26) noted but two; apparently Struthers (1923 p. 471) observed but seven in 1921 and 1922 (five at Anegado Lagoon and two at Boquerón). This agrees well with my own experience, for in 1921 and 1922 I found but thirteen birds (six at Cartagena Lagoon, six at Anegado Lagoon and one at Mayagüez). In 1923 and 1924 the increase in their numbers was very noticeable. At Cartagena Lagoon as many as twelve were sometimes in sight at one time, and on January 14, 1924, I noted fifteen. I also observed them more frequently on other parts of the Island, notably at San Juan on November 23, and January 3, 1924; Toa Baja on November 24, 1923; Mayagüez on November 30, 1923; Guayanilla on January 2, 1924; Boquerón on March 8, 1924; Cape Rojo Lighthouse on April 26 and 27, 1924, and Anegado Lagoon on December 14, 1923.

On February 27, 1924, I collected a female of this species at Cartagena Lagoon. The ovary was rather enlarged, indicating the approach of the breeding season. Unfortunately the stomach was empty so I can say nothing about the food habits. Probably they will not be found to differ materially from those of the North American variety. They are said by the country people to catch unwary birds that come too close. On October 20, 1924, I observed one pursue a Gray Kingbird for some distance. For a long time neither seemed to gain on the other, but finally the Kingbird gave a spurt and eluded its ungainly pursuer. Whether the heron was trying to make a meal of the Kingbird or not I cannot say.

While at Cartagena Lagoon the West Indian Great Blue Heron shows a decided preference for the grass association. Here its great height permits it to observe any approaching danger at a considerable distance, and it is a lucky hunter who gets a shot at one. Very few of the hunters I interviewed had ever been able to obtain one.

21. *HERODIAS EGRETTA* (Gmelin). American Egret. *Garzón blanco.*

The American Egret is a rather uncommon permanent resident at Cartagena Lagoon, although, as in the case of the Great Blue Heron, it probably nests only in the mangroves of the coastal islands. From one to four were observed on practically every visit I made to

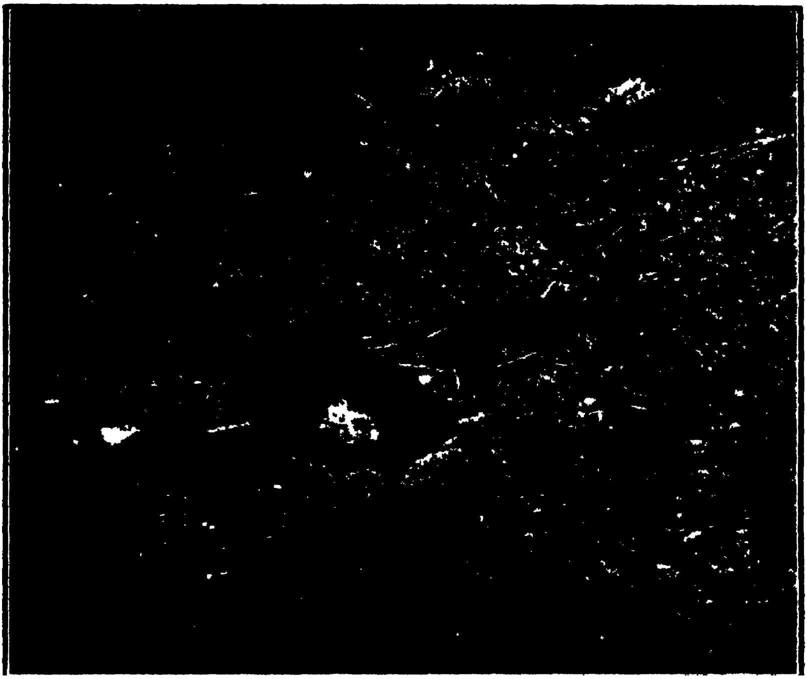


FIG. 17.—Pseudemys palustris

FIG. 18.—Ameiva exul

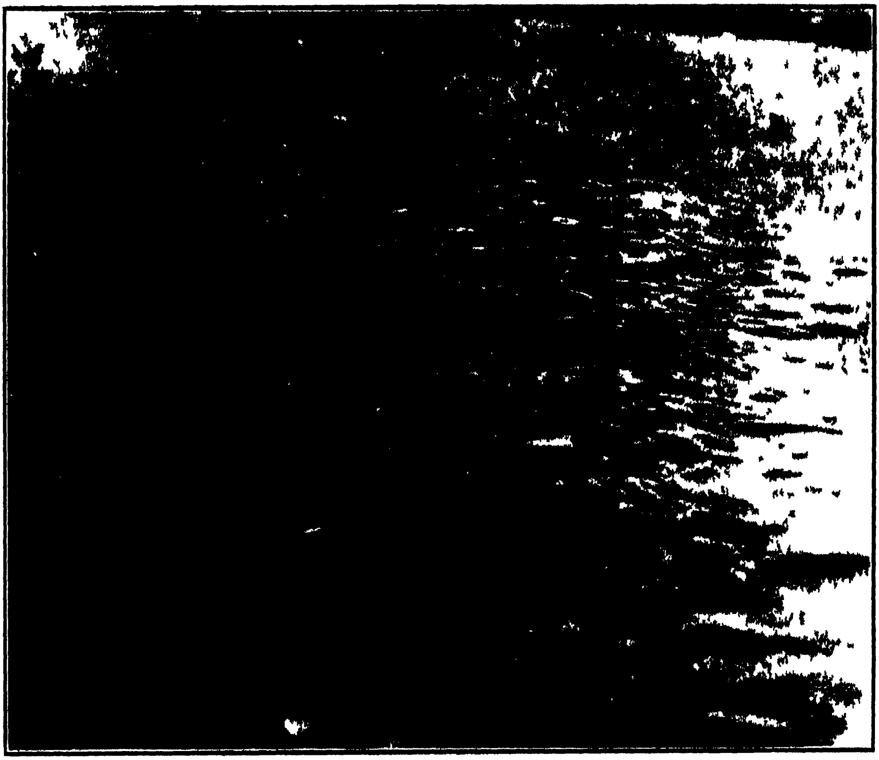


FIG. 19.—Flock of 13 Least Grebes

the lagoon, even while it was dry. The habits of this species and of the Great Blue Heron, with they sometimes associate, are almost identical, though the Egret is even warier, and I have never met a hunter who had been able to obtain one. Like the Great Blue Heron its habitat is the grassy part of the lagoon, though both on rare occasions are found in the sedges. No stomachs were available for examination. One obtained by Dr. Wetmore (1916), p. 26) contained a small goby and seven entire frogs (*Leptodactylus albilabris*), 69 per cent; a mole cricket and some grasshoppers, 15 per cent; and some vegetable matter, 4 per cent.

The only places in Porto Rico other than Cartagena Lagoon at which I have observed this species are Añasco (November 24, 1923); in the mangroves at Boquerón (March 8, 1924); and fishing in salt water near Cape Rojo Lighthouse (April 26 and 27, 1924). Wetmore (1916, p. 25) records a nest in the mangroves near Mameyes on February 14, 1912, and a breeding colony of 15 or 20 on Piñero Island, near Fajardo. They are said to nest on small islands off the south coast, but they are certainly far from common. They should be prevented from becoming exterminated, both on account of their destruction of injurious insects and on account of their beauty.

22. *EGRETTA CANDIDISSIMA CANDIDISSIMA* (Gmelin). Snowy Egret.
Garsa blanca.

The Snowy Egret is another heron which feeds at the lagoon, but apparently nests only on the mangrove islands near the coast. They may be distinguished from the white immature specimens of the Little Blue Heron as the tarsus is black and the toes yellow, while in the latter the tarsus is greenish.

The Snowy Egret is found at Cartagena Lagoon at all times of the year, but is most common during the summer months when the lagoon is dry, or nearly so, and there are extensive mudflats which it uses as a feeding ground. When the lagoon is full it feeds in the grassy areas, and occasionally in the canefields.

It is usually found in small flocks, and in the summer often in larger flocks. On June 21, 1924, I observed a flock of 120, and on July 2, 1924, a flock of 90. Sometimes it occurs in mixed flocks with *Florida c. caerulescens*, but usually each species flocks by itself.

I have noted birds with nuptial plumes as early as March 22, 1922, and as late as May 20, 1924.

On June 3, 1924, I collected a male. It measured 23.5 inches in the flesh. Its stomach contained only animal matter. Twenty-seven entire *Killifish* (*Pœcilia vivipara*) and the fragment of others constituted 78 per cent; 14 damselflies and 4 damselfly naiads formed 19 per cent. The remaining 3 per cent consisted of aquatic Hemiptera (2 *Pelocoris femoratus*), 2 per cent; and 1 *Corixa reticulata*, 1 per cent. A bird taken by Dr. Wetmore (1916, p. 25) near Río Piedras had eaten two dragonfly naiads, a small crab, a lizard and a small frog. Another from Mameyes contained gobies, Dolichopodid flies and grasshopper fragments.

Formerly these Egrets were much persecuted by plume hunters, and occasionally they are molested even yet on this account. Usually they are hunted but little, as they are wary and their flesh is not very palatable. The Mongoose cannot often molest them, so conditions seem favorable for their increase. This increase is apparently slowly taking place, and is very gratifying, as this is a beautiful species, and if abundant would probably help materially in combating the mole cricket.

23. *HYDRANASSA TRICOLOR RUFICOLLIS* (Gosse). Louisiana Heron. *Garza de vientre blanco.*

The Louisiana Heron is not very common, but it occurs quite regularly at Cartagena Lagoon during most of the year. However, there was a period from July 5 to September 23, 1924, when I did not see any. Whether they were breeding in the mangroves at this time or not would be difficult to say without further investigation. They certainly breed on the island, as on October 7, 1924, I observed two young birds about three-quarters grown. They were almost foolishly tame, though they could fly fairly well when they finally decided to do so.

While at Cartagena Lagoon, Louisiana Herons were found either singly or in small groups of two or three. They were often observed fishing in the open-water near cat-tails, and perhaps were even more often flushed from the sedges and from the Pluckea association, and they are sometimes found in the grassy regions where most of the Heron life of the lagoon congregates. They have a very harsh, raucous cry, but it is seldom uttered.

A male collected June 3, 1924, measured 26.8 inches in the flesh. Its testes were much enlarged. Its stomach contained only animal matter. Killifish fragments (*Poecilia vivipara*) constituted 27 per cent; Dytiscid fragments, 20 per cent; a dragonfly naiad, 5 per cent, and other much-comminuted insect remains, 47 per cent. A bird taken by Wetmore (1916, p. 25) had eaten a goby and killifishes.

Louisiana Herons are not much hunted, and it is doubtful if the Mongoose is very injurious to them, yet they are not so common as most of the other herons. The only localities in Porto Rico other than Cartagena Lagoon at which I have observed this species are at Anegado Lagoon, and in mangrove swamps at the Caño Corazón, near Mayagüez, and at Boquerón.

24. *FLORIDA CAERULEA CAERULESCENS* (Latham). Little Blue Heron. *Garza azul. Garza blanca. Garza pinta.*

The Little Blue is the most abundant heron at Cartagena Lagoon at all times of the year, but it does not breed there. It feeds in all the associations of the marsh proper except the cat-tail, but most commonly in the grass and sedge associations. It also feeds extensively in the canefields, not only near the lagoons, but practically everywhere in the coastal region of the Island. It is particularly abundant in the canefields near Hormigueros. Other places on the Island at which I have observed it include San Juan, Mayagüez, Añasco, Filial Amor, Cabo Rojo, Yabucoa, Boquerón, Parguera, San Germán, La Plata, Lajas, Cape Rojo Lighthouse, and Anegado and Guánica Lagoons. It probably nests almost exclusively in the mangroves of the coast. Birds are often observed flying over the hills from the lagoon towards Parguera, where they are said to nest.

Little Blue Herons occur at the lagoon in particular abundance in the fall. On September 30, 1924, I attempted to make a count of a big aggregation of these herons in the grassy region east of the lagoon. It was impossible to count them exactly, but there were certainly at least 1,000 of them. They are quite shy, and it is impossible to approach them very closely.

In Porto Rico, at least, Little Blue Herons apparently retain their white juvenile plumage for only one year. During the latter part of June and most of July only birds in the blue adult plumage were observed. In August a few white birds began to appear. On September 17, 1924, I noted that about one quarter of all the birds seen were white, and on September 30 about 500 out of the 1,000 birds seen were in white plumage. Approximately half the birds seen in the winter months are in this plumage. In February a few white birds begin to show a little blue in the plumage. By the middle of April all the immature birds show a little. By May most of them have attained the odd-appearing half blue and half white or *pied* plumage. At this stage they are known to the country people as *garza pinta*. The amount of blue in the plumage gradually increases until by the first of July virtually one hundred per cent are in full blue plumage. The white birds apparently begin coming to the lagoon to feed very soon after the breeding season. Gundlach (1878, p. 357) says that the breeding season extends from May to July. Wetmore (1916, p. 23) records eggs the first of May at Yabucoa, and Struthers (1923, p. 470) found four nests with young in the mangroves west of Boquerón June 15, 1921.

The Little Bue Heron apparently has but few enemies. The Mongoose cannot easily obtain its young unless they fall on the ground, and hunters molest them but little.

The food of the Little Bue Herons collected at Cartagena Lagoon was almost exclusively animal matter. The 0.5 per cent of vegetable matter found consisted of seeds and was probably taken in accidentally with other food. A bird taken April 18, 1924, had eaten insects exclusively. Among these were a large Dytiscid larva (25 per cent); a large smooth green caterpillar (20 per cent); a water bug, *Belostoma,* (25 per cent); a grasshopper (5 per cent), and a Naucorid (*Pelocoris femoratus*). A bird collected December 27, 1924, had obtained a more varied diet. Its stomach contained 15 entire frogs (*Leptodactylus albilabris*) constituting 25 per cent; 4 centipedes, 20 per cent: an adult mole cricket (*Scapteriscus didactylus*), 18 per cent; 1 large ground cricket, 6 per cent; 2 grasshoppers, 4 per cent; 2 Belostomidæ, 8 per cent; 1 *Pelocoris femoratus,* 1 per cent; 7 Notonectidæ (*Plea* sp), 4 per cent; 1 spider, 2 per cent. Mole crickets also formed 7.23 per cent of the food in 15 stomachs examined by Dr. Wetmore (1916, p. 24), and other insects formed 31.51 per cent.

This species is very useful in the destruction of mole crikets and other Orthoptera, despite the fact that it obtains most of its food in the swamps. Doubtless specimens obtained in the canefields would show an even higher percentage of mole crickets and other injurious insects.

25. *BUTORIDES VIRESCENS MACULATUS* (Boddaert). West Indian Green Heron. *Martinete. Martín pescador.*

The differences between the eight forms of West Indian Green Herons described by Oberholser (1912, pp. 529, 577) are so slight that I prefer to follow Barbour (1923, p. 30) in grouping them all under one name.

This is a common species at Cartagena Lagoon, and is the only member of the Heron tribe except the Least Bittern which nests in the immediate vicinity of the lagoon. It does not nest in the marsh proper, but principally in the Bamboo association, and to some extent in the larger trees which are interspersed in the Varronia association and in the Tachuelo association. Its principal feeding ground is the sedge association, although it is sometimes found in all of the associations. It is also frequently found in the canefields, and even at considerable heights in the hills near small mountain streams. It is the most generally distributed heron on the Island, but it is a rather poor second to the Little Blue Heron in abundance at Cartagena Lagoon. It prefers regions with denser vegetation where it can better conceal itself while seeking its prey. When alarmed it flies up with a scream-like *skeow* and alights on an elevated perch, if such be handy, to watch the intruder. It is the least suspicious of the herons and can often be approached closely.

Most of the nests I have observed were bulky affairs built of sticks, placed in quite inaccessible position near the tops of slender bamboos. In April, 1924, many martinetes were building nests. Apparently the main breeding season is in April and May, though I observed a nest in use on November 30, 1923. Young birds unable to fly are most frequently found in May. They are then easily captured, and are often kept as pets. In the coastal regions the nests are usually placed in the tops of cocoanuts palms, where they are quite secure against most enemies except the rats which frequent such places. It is likely that the Mongoose secures an occasional martinete in the act of feeding. Once I observed a martinete alight on along projecting into the water. Immediately a large Mongoose glided silently out on the log. The heron realized its danger in the nick of time and flew squaking away. The Mongoose sniffed the air and returned to shore, disappointed at losing a good dinner. Doubtless many less wary individuals fall victim to the bloodthirsty Mongoose.

The contents of three stomachs collected at Cartagena Lagoon were examined. One collected on December 27, 1923, was nearly empty. All that was identifiable were some cockroach fragments. Two collected on September 30, 1924, contained nothing but insects and spiders. In these two,. dragonfly naiads constituted 32 per cent; Locustid grasshoppers, 11.25 per cent; 9 *Pelocoris femoratus*, 6.5 per cent; spiders (*Aranea sp*), 7 per cent; 7 blue damselflies (all in 1 stomach), 10 per cent; *Notonecta sp.* 0.25 per cent;

1 *Belostoma* sp., 2 per cent; Hydrophilid larvæ, 0.5 per cent; adult midge 0.25 per cent. Wetmore (1916, p. 24) found that mole crickets formed 54.33 per cent of the food of 51 stomachs. Probably these form a large part of the food when feeding in the canefields. It is one of the most valuable species on the Island from the standpoint of the sugar grower, and should be protected at all times. It can be encouraged by planting bamboos along the streams and irrigation ditches for shelter. It is very adaptable to changing conditions, and is common at almost all localities in the coastal plain, though it is particularly common at the lagoons, probably because insects and other small animal life are more abundant there.

26. *NYCTICORAX NYCTICORAX NAEVIUS* (Boddaert). Black-crowned Night Heron. *Yaboa.*

The Black-crowned Night Heron is a rather uncommon permanent resident at Cartagena Lagoon, though apparently slightly on the increase. Wetmore (1916, p. 21) did not find this species, and Struthers regarded it as rare. In 1921 and 1922 I observed it there only once (April 8, 1922), while in 1923 and 1924 it was frequently observed, though never more than six in one day, and usually only one or two. During the winter only adults were noted, but in June immature birds appeared, and were observed regularly until October. An immature specimen was obtained on June 28, 1924, but the stomach contents were too much decomposed for identification. At Cartagena Lagoon *Yaboas* are usually observed only when flushed from the dense cat-tails or tall sedges in which they spend the day. Doubtless they could be observed feeding after dusk. They are regularly hunted by the country people who say that the flesh is very good. It does not nest at the lagoon.

27. *NYCTANASSA VIOLACEA* (Linnaeus). Yellow crowned Night Heron *Yaboa.*

The Yellow-crowned Night Heron is a more generally distributed bird in Porto Rico than the Black-crowned, but it is observed far less frequently at Cartagena Lagoon. Like the Black-crowned species it is much hunted for its flesh. That is said to be the reason for the present scarcity of these two species. Bowdish (1902, p. 359) found it common at the localities he visited. He found fiddler crabs, eels and crawfish in the stomachs which he examined.

28. *PORZANA CAROLINA* (Linnaeus). *Sora Gallareta chiquita.*

The Sora is a tolerably common winter visitant at Cartagena Lagoon. It arrives in October (October 14, 1924), and leaves in April (April 8, 1922; April 18, 1924). While at the lagoon it is found most commonly in the Pluckea and sedge associations, though it often ventures into the cat-tails. Occasionally they can be observed walking on the pond-lily leaves, and even on the floating Pisiias. When flushed they fly with dangling legs to the nearest shelter, which more often than not is a clumb of cat-tails. During the winter they are as a rule quite silent, but as spring approaches their characteristic whinny is heard with greater frequency. While in Porto Rico the Sora has but few enemies, as there are not many hunters who waste their ammunition on so small and elusive a bird, and I doubt if even the Mongoose is quick enough to get very many of them. No stomachs were available for examination.

29. *PORZANA FLAVIVENTRIS* (Boddaert). Yellow-bellied Rail *Gallareta chiquita.*

The Yellow-bellied Rail is a permanent resident at Cartagena Lagoon. While it cannot be said to be very common, it is commoner than it is usually supposed to be, since on account of its retiring habits it easily escapes notice. It occurs almost exclusively in the sedge and grass associations. On being flushed it flies quite swiftly for a short way and then suddenly drops into the vegetation, from which it is usually impossible to flush it a second time. On one occasion (May 23, 1924) one stalked ahead of me through the cat-tails for a considerable distance as though trying to lead me away from its nest, but search as I would I could not find it. So far as I can ascertain the nesting habits of this species remain undiscovered. I collected two birds for examination of the stomach contents. One collected on February 19, 1924, contained animal matter, 99 per cent (entirely insects); and vegetable matter, 1 per cent (1 small unidentified seed). The insect matter consisted mainly of four Syrphid pupæ and the fragments of a Lamellicorn beetle. The stomach contents of a male collected April 4, 1924, consisted of 96 per cent of animal matter and 4 per cent of vegetable matter. The vegetable matter was green algæ with a little rubbish. The identified animal matter consisted of 1 Dytiscid larva (20 per cent); 1 Syrphid fly (13 per cent); 2 Notonectidæ (10 per cent). This bird had also eaten six down feathers, totalling 16 per cent of the stomach contents.

This meager data indicates that the Yellow-bellied Rail is a [illegible] species. It is too small to be considered a game bird. It is a useful and interesting member of the Porto Rican avifauna.

30. *IONORNIS MARTINICUS* (Linnaeus). Purple Gallinule. *Gallareta inglés.*

The Purple Gallinule is not uncommon at Cartagena Lagoon, where it is a permanent resident. It is a bird of the cat-tail, sedge, grass and Pluckea associations, and shows but little partiality towards any one of these, except that for nesting it prefers the cat-tails. One seldom seems more than ten Purple Gallinules in a day at the lagoon. If alarmed while feeding it runs very fast, occasionally using its wings to gain increased speed in propelling itself through the vegetation, until it reaches the protection of the nearest clump of cat-tails. If the distance to be covered is too great it takes wing. In one case a bird flew into the top of the cat-tails and gave vent to its displeasure in a series of rail-like cackles before disappearing into the hidden recesses of the cat-tails. I have never observed this species swimming They are usually flushed singly or in pairs One seldom catches more than a fleeting glimpse of them as they disappear into the cat-tails, so they are very hard to shoot An experienced hunter with whom I talked said he had been trying for ten years to obtain some Purple Gallinules, and in that time he had succeeded in shooting just one, and he is no mean marksman, as I can testify after seeing him bag five ducks out of six shots, each of them single birds.

The Purple Gallinule has two nesting seasons at Cartagena Lagoon The principal one is in April and May, but there is another extending from the last of August through October.

In 1924 the first evidence I had of the breeding season was on April 8 when I observed a Purple Gallinule fly into the cat-tails with a large leaf in its mouth During 1924 I discovered eight nests of this species Six were in May, one in September and one in October. All but one were placed in cat-tails at heights ranging from six inches to six feet above the water, most of them being from two to three feet above it This constitutes an important difference between the nesting of this species and that of *Gallinula chloropus portoricensis* All of these cat-tail nests were more or less substantial bulky platforms of cat-tails leaves In two of them the leaves used in construction were still green. The eggs are light buff with larger rufous brown spots and blotches than those of *G. c. portoricensis.* Another important difference is that all the eggs of Ionornis have more or less distinct spots and blotches of pale lavender, especially at the

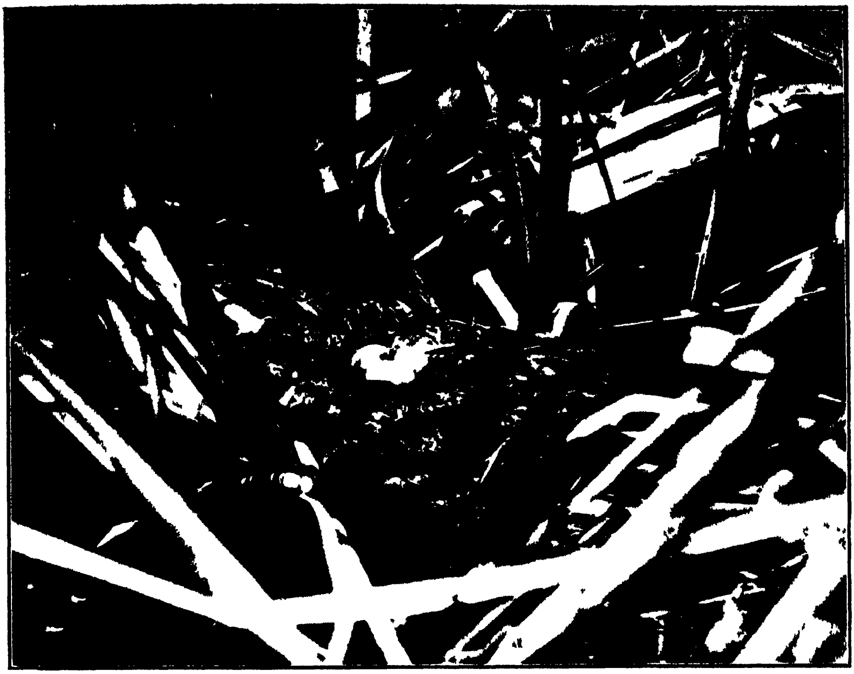


FIG. 20.—Nest and Eggs of Least Grebe. Cat-tail Association. September 20, 1924

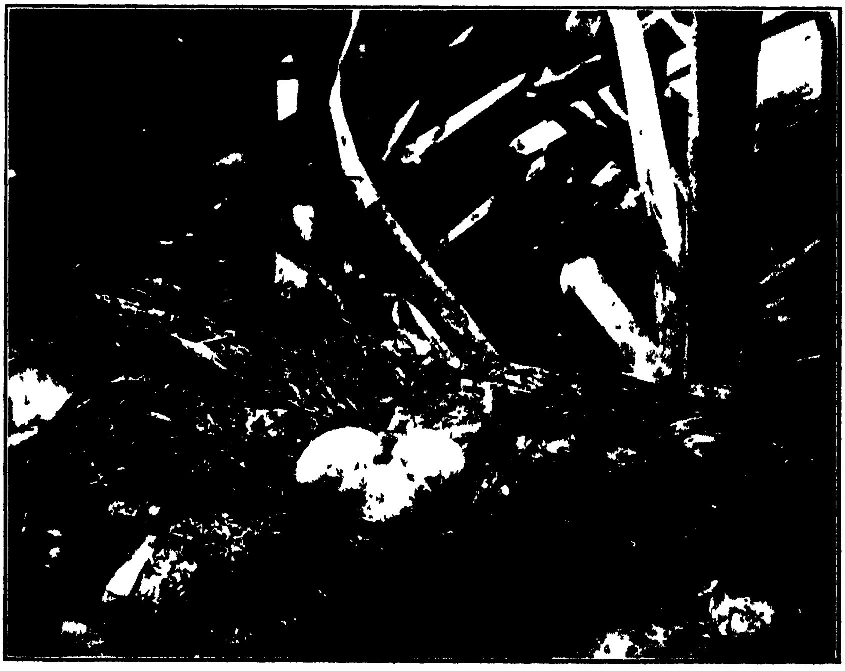


FIG. 21.—Closer View of Same Nest

FIG 22—Nesting Site of West Indian Pied billed Grebe

FIG 23—Newly Hatched West Indian Pied billed Grebe

larger end. The measurements of three eggs from different sets were 1.60 × 1.15 inches; 1.62 × 1.15 inches and 1.7 × 1.2 inches. The number of eggs varied from two to six.

The one nest which was not in the cat-tails was found on August 30, 1924, when it was partly completed. It was constructed of the stems of sedges, and was placed in a clump of sedges at a height of one foot above the water. The nest was deserted before any eggs were laid in it The other fall nest was found on October 14, 1924. It was placed four feet up in some cat-tails, and at that time contained one egg. On October 17 the eggs had increased to three.

The first spring nest that I located contained two eggs, one of them pipped, on May 9, 1924. In the second nest the young hatched May 16. The third nest had five slightly incubated eggs on May 16, but this was the lowest nest found and was later broken up, presumably by a Mongoose. The fourth nest was also a low one. It contained three eggs on May 16, which had increased to four some time before May 20, but this nest was likewise broken up. The fifth nest contained two eggs which hatched on May 23. The sixth nest deserves most mention. I first discovered it on May 16. It was built of green cat-tail leaves and placed in some fifteen-foot cat-tails at a height of six feet above the water. At that time it contained six eggs, at least one of which was only slightly incubated, as I learned by accidentally breaking one While I was examining the nest one of the adult birds alighted on some nearby cat-tails, but on seeing me it gave some startled clucks and cackles and did not return again within the hour and a half which I waited in concealment. When I visited the nest on the morning of May 27 one egg had hatched and another was pipped, and had hatched when I visited the nest a second time about an hour later. I took the two young birds back to Mayagüez with me, leaving the three unhatched eggs in the nest. The next time I visited the nest (May 30) it contained two eggs and the shell from which a young bird had hatched, which I removed On my next visit (June 3) the nest contained the empty shell from which the fourth young had hatched, and one rotten egg. The long intervals between the hatching of the young indicates that incubation is begun before all the eggs are laid, and that they may not all be laid on successive days. The young on hatching were covered with a rather stiff black down, except for a few white hair-like feathers on the head and throat. The bill was red at the base and black in front. The egg tooth and a region around it were pure white. The iris was was such a very dark brown that it appeared black unless examined closely, in which case it could be distinguished from the jet plack pupil and feathers surrounding the eye. The feet and legs were pinkish flesh color. They made a peeping sound resembling that made by the young of domestic fowl, but rather more discordant. I kept them in a small coop, at night placing them in a brooder improvised from a couple of tin cracker boxes and a kerosene lamp. They fed voraciously upon cracker crumbs moistened with water, cooked oatmeal and hard-boiled egg. They would take food only when it was offered to them in one's fingers; any that dropped on the floor would not be touched. They liked to be in the sunshine, and when in it they would doze quietly unless they heard me coming. Then there would be a clamor for food, and when it was offered they would vie with each other for the first morsel, picking at the white spots on each other's bill, and trying to push each other out of the way. The more aggressive one sometimes grabbed its weaker brother's wing in its bill. The sounds they made when they heard me approaching were loud discordant twitterings, not unlike those of young swallows in the nest. Whenever they were not dozing their wings were constantly in motion, wiggling back and forth alternately, beating the air until it seemed as though they would wear themselves out.

By June 1 I noticed that the red on the bills was getting less bright. The weaker bird died at the age of 8 days as the result of a chilling in a hard rain. It measured 4.25 inches at that time. After the surviving bird was about 10 days old I let it out to run in the grass occasionally. It had an annoying habit of running about for a few minutes and then squatting and hiding. Even though I knew almost exactly where it was, so perfectly did it conceal itself even where the grass was comparatively short that I had great difficulty in finding it. Once it got off a little farther than usual, and it took me nearly an hour to find it, and even then I probably would not have found it if it had not uttered a couple of peeps which led me nearly to it. When I once found it I had no difficulty in capturing it, as it was not afraid of me, but its natural instinct seemed to tell it to keep concealed. This accounts for the very few downy young that one sees in their native haunts. When not concealed this bird kept up an almost incessant peeping. It had a sharp hook on the pollex which it used to aid it in getting through dense vegetation rapidly. This lived to the age of 30 days, but in that time it appeared to have increased scarcely at all in size, nor did it have a single feather other than down feathers. It had been fed finely cracked shells for lime, and grift, in addition to its regular diet, but it probably lacked some essential article of food, though this hardly seems possible, as it had quite a variety. It was very fond of mangos and bananas. The direct cause of its death was a chilling. Natives claimed to have raised them by feeding them nothing but polished rice.

I can say but little about the food of this species, as I obtained no stomachs for examination. In Gundlach's time the Purple Gallinule was very common, and did much damage by eating rice and breaking down the stalks. At present practically no rice is grown on the Island. Field observations show that it eats tender blades of grass, especially of *Hymenachne amplexicaulis*, and it is said by the country people that its food consists almost exclusively of this.

The Mongoose is an enemy of this species when it nests near the ground, as it is of all ground-nesting birds, and probably it obtains many a tidbit of young gallinules. This species is now so shy that hunters do not materially lessen their ranks. They are perhaps the most beautiful of the Porto Rican game birds, and the pity is that they are not more abundant.

31. *GALLINULA CHLOROPUS PORTORICENSIS* (Danforth). Porto Rican Gallinule. *Gallareta.*

The Porto Rican Gallinule is an abundant permanent resident at Cartagena Lagoon. It is preeminenty a bird of the grass, sedge and Pluckea associations, though it is very frequently observed in the open water and cat-tail associations. It reaches the pinnacle of its abundance in the grass association, and nests in all except the open-water association.

The principal characters which distinguish this form, which I am describing in the October 1925 *Auk*, from its allies are: The tarsus averages slightly longer than the North American *G. c. cachinnans* and shorter than *G. c. cerceris* of St. Lucia and Grenada. The frontal shield is conspicuously larger than in the North American bird. The coloration is much darker, and the brown on the back is confined mostly to the middle back.

The cackling of the Gallinules is the most characteristic sound of the marsh, and can often be heard from a considerable distance as one approaches it. They are not as aquatic as the Coot, and keep more to the regions of dense vegetation, though they swim readily and sometimes associate with the Coots in the open-water areas. Flocks of scores may be noted resting and feeding in the grassy region at the east end of the lagoon. They can be distinguished at a great distance by means of their broad scarlet frontal plates. When the lagoon was drying up in June large aggregations of Gallinules were noted on the mudflats near Las Cañitas. On the slightest alarm they would make for the cat-tails, swimming if the water were deep enough to permit it, otherwise they would splatter over the shallow water and mudflats, beating their wings to hasten their progress. Once in their cat-tail retreat they would not emerge until the coast had been clear for some time, for they are suspicious birds.

The country people hunt Gallinules with dogs which drive the birds, ever reluctant to take flight, towards their masters, who then kill them with sticks. Many adults as well as immature birds not yet able to fly are caught in this manner. On May 9, 1924, I was presented with a live and apparently uninjured young bird captured in his manner. It was about half grown, but its wing quills were still just budding sprouts, so, of course, it was unable to fly. Its frontal shield was not yet red. Unfortunately it escaped before I had had it very long.

The nesting season of the Porto Rican Gallinule is practically continuous throughout the year, except for periods when the lagoon is dry. Eggs and young in all stages can be observed in almost every month, but the main breeding season appears to be from February to May, and I have found many more nests in March than in any other one month.

The nests vary greatly in their construction and location. Some are floating nests built of cat-tails leaves and anchored to cat-tail plants Others are built of sedge stems and placed on the ground among the sedges or built up from the bottom in shallow water. Some are built of grass stems and roots and placed among the grasses, either on the ground or floating and anchored to a tuft of grass. Most of the nests are not much more than open platforms, but occasional nests are arched over and resemble a giant Meadow-lark's nest They are always built of the same kind of plant as that which forms the surroundings. Usually they are placed where the surrounding vegetation conceals the nest to some extent, but I have found some nests in very exposed positions, such as in patches of grass no taller than a new-mown lawn. One nest was even anchored to a wire fence in the open water. But they are never placed more than two or three inches above the ground, while those of *Ionornis martinicus* are always placed higher than this. The eggs of *G. c. portoricensis* are buffy, spotted and speckled with rufous brown, but these spots are not as large as in the case of *Iornornis*, and they lack the pale lavender markings. They are also slightly larger, though the difference in size is not very apparent. Their measurements average about 1.8 × 1.2 inches. The number of eggs varies from three to eight, though nests with over six are very rare, and the usual number is four or five. As many dozens of nests were found during each season, I feel that I can speak quite positively about this. I have been unable to ascertain the incubation period, as eggers made way with the eggs before they hatched in every nest I was trying to keep under observation.

The black downy young with red bills are frequently observed, both before they have left their nests, and afterwards as they patter around over the floating Pistias or scramble around among the dense vegetation, usually with an anxious parent swimming around near nervously clucking. Apparently the youngsters cannot swimm well, for they are never observed in this act. On one occasion I observed an adult transport a downy young bird across a stretch of open water on its back, clucking loudly as it did so.

The Porto Rican Gallinule is so beset with enemies that it is a wonder that any survive. Eggers search the marshes so systematically that only a small proportion escape their eagle eyes, and many of those that do escape them fall prey to the Mongoose. Hunters obtain hundreds of gallinules a year at the lagoon, and birds of prey, notably the Duck Hawk and Red tailed Hawk, obtain their share. But the Gallinule is so adaptable that it persists in large, though constantly diminishing, numbers.

Vegetable matter formed 100 per cent of the food in three adult stomachs examined. Of this, pondweed (*Naias guadeloupensis*) formed 95.3 per cent. Seeds of *Persicaria portoricensis* formed 2 per cent, and the other 2.7 per cent consisted of rubbish, which included several pieces of bark. Coarse sand was present in considerable quantities, forming 9.3 per cent of the stomach contents.

Field observations show that these Gallinules also eat considerable quantities of tender grass stems (*Hymenachne amplexicaulis*).

This species is thus harmless in its food habits. It is strictly a marsh bird, common in all the plant associations of the marsh proper, where it associates to some extent with the Coot, though less strictly aquatic in its habits. The marsh is not essential to its existence however, as is shown by the fact that the country people often raise them with their domestic fowl. But in the wild state they are never found far from the marshes, as here it finds the vegetation which provides the dense shelter so much to its liking, and here it finds the tender green stuff which forms its favorite article of diet. It is one of the most valuable native game birds, and its abundance for future generations should be insured by absolutely preventing the taking of eggs, and by prohibiting hunting at least during its main breeding season, which extends from February to May, and a much longer closed season would be preferable.

32. *FULICA CARIBAEA MAJOR* (Danforth). Porto Rican Coot.
Gallinazo.

The Porto Rican Coot is the most abundant permanent resident at Cartagena Lagoon. Approximately 3,000 birds are present at all times of the year when the water is deep enough to permit them to swim. It is for the most part a bird of the open-water association, though it feeds quite extensively in the sedge and grass associations, and nests mostly in the cat-tail, sedge and grass associations.

While feeding the Coots usually congregate large rafts. These rafts are composed for the most part of the one species, but it is not unusual for a few Porto Rican Gallinules and Allen's Ruddy Ducks to associate with them. While swimming the Coots jerk their heads back and forth and frequently emit little croaking sounds. When alarmed they patter over the water for a considerable distance before getting into the air, using both feet and wings and producing a peculiar swishing, splattering sound. Occasionally they take to the cat-tails for refuge, but ordinarily they fly to some distant part of the lagoon. Unless frightened again they do not return for hours. Hunters are well aware of this fact, and station boys at many points around the lagoon to scare up the birds wherever they attempt to alight, and force them to fly near the cat-tails where the hunter is concealed.

At times many Coots may be observed resting on the grassy flats. They also feed to quite an extent upon the tender grass shoots, which in certain favored areas they keep plucked as fast as they appear, producing the effect of a closely mowed lawn. When the receding waters of the lagoon cause the coots to congregate more closely they become rather quarrelsome. When a bird approaches too closely to another in a flock it receives a (savage) jab and is driven away. Usually it does not retaliate. On one occasion (September 9, 1924) I observed three Coots engaged in a free-for-all fight. The birds would swim towards each other, using their wings to gain greater impetus. They made savage jabs at each other's heads until each was satisfied, when they swam off in different directions.

They are noisy birds, and at times the marsh resounds with their high cackling notes, which can be heard from a great distance. They are quite similar to some of the notes of the Porto Rican Gallinule, but louder. Another note which is frequently heard is similar to the sound produced by pouring water out of a glass decanter.

Until recently the breeding Coots of Porto Rico were supposed to be *F. americana*. Since publishing his "Birds of Porto Rico" in 1916 Dr. Wetmore began to suspect that it might be *F. caribaea* instead. All my specimens and all the birds observed closely in the field proved to be a heretofore undescribed race of *F. caribaea* which differs from *F. c. caribaea* (Ridgway) chiefly in its much larger size. I am describing as *F. c. major* in the October 1925 *Auk*.

As the lagoon is drying up many immature birds not yet able to fly are caught on the mudflats and in the cat-tails with the aid of dogs. The young keep their down for a long time, and are more than half grown before their wing quills are sufficiently grown to enable them to fly. In the oozy mudflats the birds could neither run nor fly, and there the country people picked them right up in their hands.

These birds stand in shallow water to bathe. They dip their head in water, throw water over their backs and then shake themselves.

I have sometimes observed what I believe to be the courtship of this species. The male swims around the female with wings half raised and tail elevated so as to display the white under tail coverts to full advantage. All the feathers are fluffed out and it appears very large. Then it pursues the female for a distance, but I have not observed actual mating to follow this performance.

Nests and eggs of the Porto Rican Coot may be found at any time of the year except when the lagoon is dry. However, more birds nest in April, May, and October than in any other months.

The nests are very similar to those of the Porto Rican Gallinule, but a larger proportion of them are floating affairs, and a slightly larger proportion of them are built among the sedges. Out of the three hundred odd nests found at Cartagena Lagoon about forty per cent were placed in the sedges. Most of these were built of sedge stems, particularly those of *Eleocharis*. Stems and leaves of *Persicaria portoricensis* are also frequently used in nest construction. About forty per cent of the nests were placed in the grass association, but most of these were anchored to the herbaceous shrub *Sesban* *emerus* which grows commonly in this association. These were mostly constructed of sedges or cat-tail leaves. A few nests were placed right in the grass, in which case they were made of grasses. About fifteen per cent were anchored among the cat-tails and made of dead cat-tail leaves. Five per cent or less were in the Pluchea association, but only at times of very high water.

The number of eggs in a set varies from one to eight. Five or six is the most common number, while sets of seven and eight are very rare. The eggs are immediately distinguishable from those of the Porto Rican Gallinule by their much larger size and the fine and uniform speckling. They are very pale buffy white, sometimes grayish-white, finely and uniformly speckled white black, occasionally with chocolate. They measure 1.95 × 1.3 inches.

The downy young appear to be quite similar to those of *F. americana*. I have never had them in my hand, but in the field they appear to be black with a red bill. They are expert divers. When the mother gives the alarm note they dive so quickly that one is lucky to catch a glimpse of them After they have dived the mother swims anxiously about making little croaking notes. If one stands motionless in the cat-tails or other dense vegetation he will often be rewarded by seeing a female Coot followed by one or more downy young swimming around among the stems of the plants. The young apparently accompany the parents until they are about half grown. After leaving the parental care the immature birds show a tendency to flock together.

The Porto Rican Coot is so thickly beset with enemies that it seems marvellous that any are left. It is at present the best game bird on the Island that is at all plentiful, and its flesh is the most palatable of any of the lagoon birds I have tasted. The Black-bellied Tree Duck is the only species the flesh of which is more sought after. Therefore most hunters would rather make a large bag of Coots than of almost any other species, and hundreds are obtained every year at Cartagena Lagoon. Their eggs are large and of good flavor and easily found. Several thousand eggs a year are taken by eggers. They search the marshes so systematically that about 98 per cent of the nests I found were robbed within three days of the time I found them. This made it impossible to carry on any intensive study of the nests. As an example of the large number of eggs which are taken I might mention a statement made by a hunter friend of mine that he and one other man collected ninety Coot eggs at Cartagena Lagoon on December 16, 1923, which is not during the

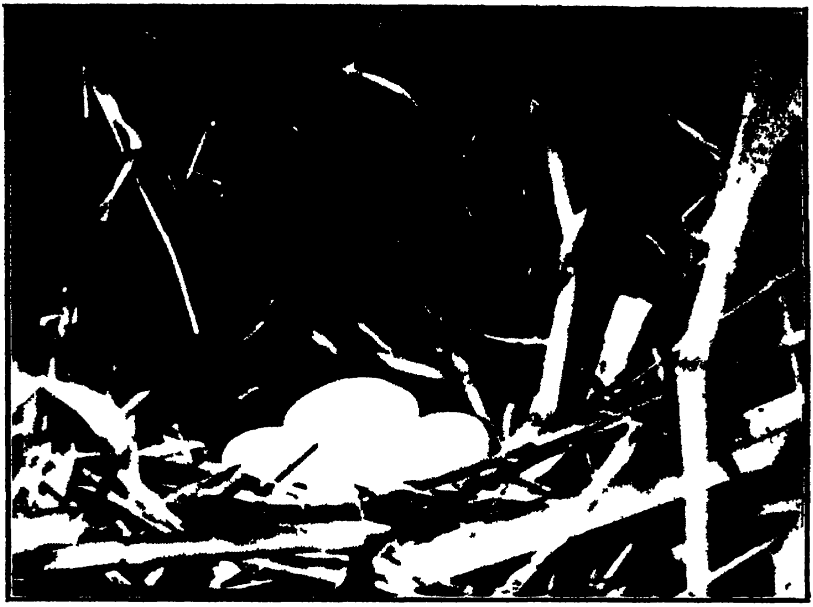
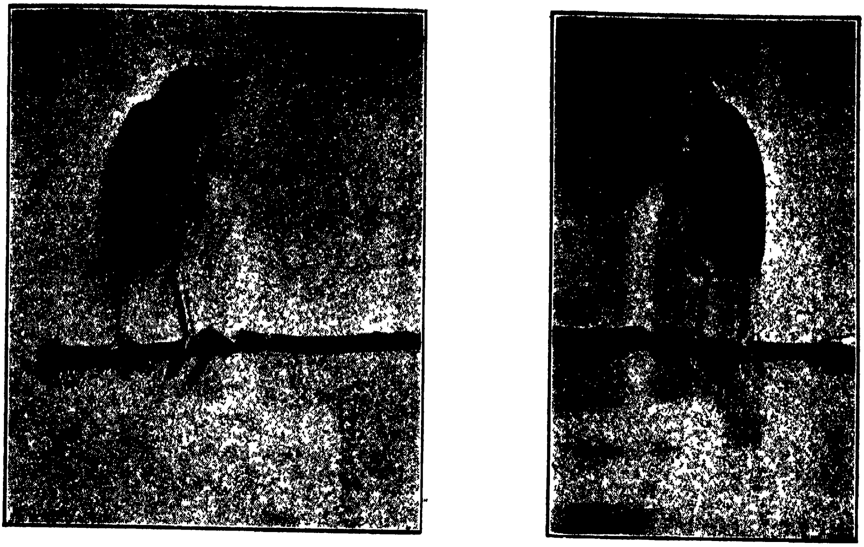


FIG. 24.—Nest and Eggs of Allen's Ruddy Duck

FIG. 25.—Nest and Eggs of Allen's Ruddy Duck



FIGS. 26 AND 27.—Captive Young West Indian Green Heron

FIG. 28. — Downy Young Purple Gallinule

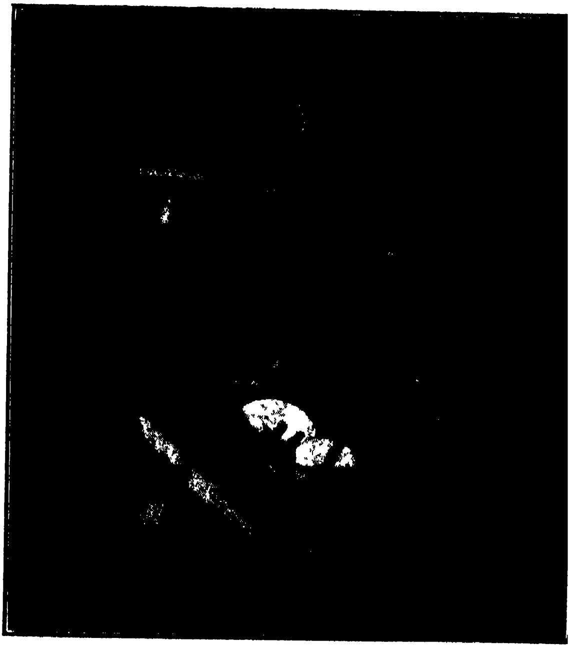


FIG. 29.—Nest and Eggs of Porto Rican Gallinule

main breeding season. In March I have seen the regular eggers coming out of the marsh with a burlap grain sack half full of eggs, and they do this repeatedly. The Mongoose is also very fond of Coot eggs and young Coots. Many a nest shows evidence of having been ravaged by this destructive animal. In the winter of 1921–22 and in the beginning at least of 1924–25, a Duck Hawk resided at the lagoon and fed principally upon Coots. The Red-tailed Hawks from Tinaja Hill likewise show interest in the Coots, though I have never actually observed one catch one. Another hazard which the Coot encounters is that of the sudden increase in volume of the lagoon. Many Coots had nests early in September, 1924. Then on September 27 a heavy rain increased the depth of the lagoon by over a foot and submerged many of their nests.

The contents of four stomachs, three taken in September and one in January, were examined. The food found was entirely vegetable matter, and 79.2 per cent of it was pondweed (*Naias guadeloupensis*). The other 20.8 per cent consisted of seeds of *Persicaria portoricensis*. Besides this food the stomachs contained a lot of fine sand, forming 35 per cent of the total stomach contents. Field observations show that this species also eats many tender grass shoots (*Hymenachne amplexicaulis*), and a bird taken at Guánica by Dr. Wetmore (1916, p. [illegible]5) "had eaten a large quantity of grass or sedge, with a few small roots". This species is not entirely herbivorous, as is indicated by the stomach contents of a bird collected by Wetmore on Culebra Island, which included a water scavenger beetle, some small crustaceans and some eggs believed to be of crustaceans.

The Porto Rican Coot is thus shown to be either neutral or slightly beneficial in its food habits, and it is of great value as a game bird. I think I may even say unhesitatingly that it is the most valuable game bird in Porto Rico. One of the surest ways to diminish the numbers of any bird is to persistently rob its nests. Unless this pernicious practice is stopped the Porto Rican Coot will undoubtedly become a rare bird. Stringent measures should be taken to stop this practice if future generations are to continue to have the privilege of hunting Coots. The Coots should also be protected from March 1st to December 1st.

38. *HIMANTOPUS MEXICANUS* (Müller). Black-necked Stilt.
Viuda. Zancudo.

The Black-necked Stilt is a common summer resident at Cartagena Lagoon. It is never found there in the winter months, nor have I found it at any other place on the Island during these months. Other ornithologists record it as a resident species, so it may be found in some of the more remote mangrove swamps at the time. At Cartagena Lagoon the first birds were noted on April 8, 1922, though I had observed a few at Anegado Lagoon on March 4. In 1924 the first Stilts appeared on March 11, and none were seen after October 7.

This is primarily a bird of the grass association. As the lagoon is drying up they feed farther and farther out towards the center of the lagoon in the open-water association. Birds are sometimes seen in any of the associations of the marsh proper except the cattail. Except while nesting they are usually found in small flocks. They are very noisy birds, particularly during the breeding season. Their sharp *kek*, *kek* is one of the characteristic sounds of the marsh in summer. They often wade in water up to their bellies, which, as their legs are so long, means that they can feed in pretty deep water. They fly with neck and feet extended. They are quite shy, and except when they are defending a nest or young it is difficult to approach very close to them. With a few sharp call notes they are off for a distant part of the marsh as soon as they regard themselves in danger. At times of low water they may often be observed lying and basking in the sun on the hard-caked mudflats which then occur. Their legs are so long that they have difficulty in keeping their balance in a strong wind. In order to keep it they spread their wings and quiver them, either directly facing the wind or with their back directly towards it. A curious feature about this species is the upper mandible, which is quite flexible, especially near the base.

When the Stilts first appear in the spring they are in flocks of from 15 to 25. By March 25 they had begun to separate into pairs, each pair picking a certain portion of the marsh. But for some time the birds did not defend their portion of the marsh with great zeal, and a central flock remained. Gradually this flock became smaller and smaller until by April 18 it contained only eight birds. All the rest were in pairs, each in its own area of the marsh. When two pairs chanced to come together fighting ensued, for by that date the birds were very zealous in the defense of their territory. Courtship was also taking place. The male (distinguished from the female by his jet black upperparts, while those of the female are dark brown) would spread his wings and walk around near the female in semicircles or sometimes in zigzag lines resembling the line of march of a drunken man, but the female appeared to pay no attention to him. By April 22 all the birds were paired. On April 30 there was another small influx of migrants, perhaps from nearby regions. The new arrivals consisted of a small flock of unpaired males and another of unpaired females. By this time the paired birds were more pugnacious than ever in defending their territories. One pair even chased off a Turkey Vulture which ventured too near. By May 2 all the new arrivals were paired and in possession of territories except a small flock of excess females. A male collected at this time had greatly enlarged testes. On May 9 many pairs had nests under construction, but I found none with eggs then. On May 20 most of the birds had complete sets of eggs, but all of these nests that I discovered were robbed by eggers soon after the sets were completed. These first nests were all in little hummocks of grass and *Persicaria* surrounded by shallow water at the east end of the lagoon. The nests were made of grasses and concealed in the centers of the little hummocks. This is evidently the favorite nesting site of these birds, but later nests varied greatly from this type of nesting site, as will be shown later. The number of eggs in these first layings varied from five to seven. They were extremely variable in color and markings, even within the set. The commonest type were buffy-clay color thickly spotted with rufous-brown, especially at the larger end, but with great variation in the size and color of the spots. Some eggs also had a few pale lavender spots. Some were olive green spotted with chocolate. The background of some was almost copper-colored. Some measurements taken were 1.72 × 1.25 inches; 1.75 × 1.30 inches; 1.87 × 1.08 inches. This shows that they vary greatly in shape as well as color. The last one mentioned was from a set in which all the eggs were long and pointed, this was the extreme one. The birds become much excited when their nests are approached and make aerial dashes at the intruder, almost hitting him in their downward swoops, and all the time keeping up a racket of sharp *kek, kek* notes.

After the first nests were destroyed the Stilts immediately began to build again. This time they showed great ingenuity in concealing their nests. The colony then spread over the marsh and the number of ways devised and variety of places in which nests were found was astounding. Space permits me to mention only a few of them. One was built of sedges in a small pile of dead Sesban brush in the grass association. One was built on a little hill of fairly firm bare mud surrounded by soft oozy mud. The top of this little mud-hill was hollowed out and a few roots placed in it, on which the eggs were laid. Several nests were built on a low mudflat island which was practically unapproachable on account of the deep morasses on each side of it. One of these was composed only of a little earth scraped together with the addition of a very few broken twigs. It was scarcely distinguishable from the rest of the island. Other nests were built of Sesban stems and hidden in the Persicarias. One nest was even built right in the open water where it was six inches deep. It was constructed of Naias, and was built up from the bottom. All these nests were built in late May and June. None contained over five eggs. Most had four, while a few had only three. But despite the precautions of the birds practically every egg fell victim to the eggers, largely due to the extra dry season which permitted the eggers to obtain the eggs more easily. In 1922 quite a large number of young were raised, but in 1924 so far as I know only two pairs succeeded in even hatching any eggs, and I believe something happened to their young before they were very old, so it is very doubtful if a single bird was raised in 1924.

By the latter part of June the adults had begun to flock again, and by the middle of September all the Stilts at the lagoon (155 by actual count) had formed one compact flock. This count was made on September 17. By September 20 only about 50 were left; on September 23 there were 20; on September 27 and September 30; sixteen; on October 7, five. After that none were seen.

The three stomachs examined contained nothing but insect matter. A bird collected April 4, 1924, had eaten two Dytiscid larvae (6 per cent), and adult Dytiscids (94 per cent). The stomach of one collected May 2, 1924, contained Syrphid larvae (93 per cent); an adult Syrphid (1 per cent); a Dipterous pupa (1 per cent); and fragments of a Dytiscid beetle (1 per cent). One collected October 7, 1924, had eaten exclusively the larvae and pupae of Anopheles mosquitoes. Sixty entire pupæ, 5 entire larvæ and the fragments of many others were found Two birds collected by Wetmore (1916, p 45) had eaten aquatic Hemiptera and small fish scales.

The large number of Anopheles mosquito larvæ and pupæ eaten alone entitles this bird to protection, for Anopheles is the carrier of the much dreaded tropical malaria. The taking of eggs should be forbidden, and the Stilt should be placed on the protected list, as its flesh is of little value as food. It is strictly a bird of the marsh, but it is very adaptable and can live in any part of the marsh except the cat-tails and very deep open water. It obtains its food from the marsh and is well adapted to feed in quite deep water by reason of its very long legs. It occurs in salt as well as fresh-water marshes, but in Porto Rico it appears to prefer the fresh.

34. *CAPELLA GALLINAGO DELICATA* (Ord). Wilson's Snipe. *Becacina.*

The Wilson's Snipe is a winter visitant of somewhat irregular occurrence and abundance at Cartagena Lagoon. In the winter of 1921–22 they arrived early and were very abundant. In 1923–24 they did not arrive until December 27, and after that not over eight were seen on any one day, and usually not over four. In the fall of 1924 one was noted on October 7, and no others before I left (on the 22nd). The dates of spring departure were March 22, 1922, and April 15, 1924. In the winter of 1921–22 it was also seen abundantly at Anegado Lagoon. My only Porto Rican records for this species from other localities are a bird seen December 26, 1923, in a canefield at Añasco and one February 13, 1924, in a small fresh-water swamp at Mayagüez.

At Cartagena Lagoon the Wilson's Snipe shows a decided preference for the sedge and grass associations, and is found in particular abundance among the Persicarias. It is occasionally found in the Pluckea association, and once I flushed one in the Varronias.

A stomach from Río piedras examined by Wetmore (1916, p. 45) contained aquatic Hemiptera and Coleoptera, Mole Cricket remains, grass and sedge seeds. Probably the diet of the Cartagena Lagoon birds would be somewhat similar.

This is a game bird, but it is little known and is practically never obtained by local hunters. Its flight is so swift and tortuous, and it springs from the vegetation so suddenly that it startles any but the experienced hunter. This makes it a very difficult bird to shoot, and in Porto Rico, where it is not a common species, very few gain the needed experience, so I consider it fairly safe while there, and do not believe it needs any special protection.

35. *MICROPALAMA HIMANTOPUS* (Bonaparte). Stilt Sandpiper. *Putilla.*

The Stilt Sandpiper is a tolerably common migrant at Cartagena Lagoon, occurring only during August and September. In 1924 the first arrivals were noted August 20, and the species was present until September 27. On August 20 I observed at least thirty-five (collecting some for positive identification), and on September 17 there were at least fifty. Lesser numbers were seen on other days. They were feeding on the mudflats and shallow water areas of the open-water association. They associated freely with Semipalmated

Sandpipers and Lesser Yellowlegs. Such careful scrutiny is necessary to distinguish them in the field from the latter species that doubtless many are overlooked.

Seven stomachs (five collected on August 20 and two on September 17) were available for examination. Animal matter composed 70.1 per cent of the food, and vegetable matter 29.9 per cent. Bloodworms (Chironomid larvæ) were the largest food item, forming 72.8 per cent of the animal food. From 150 to 600 bloodworms were found in all but two of the stomachs. Dytiscid larvæ formed 15.5 per cent, small Planorbis snails 7.1 per cent, and mosquito larvæ 0.8 per cent of the animal matter. The vegetable matter was composed of seeds. Seeds of *Persicaria* formed 80 per cent of the vegetable matter; seeds of *Sesban emerus* 7 per cent; seeds of Compositæ 10.2 per cent, and rubbish 2.8 per cent. This is a useful species, obtaining what food it can on the mudflats. Like most of the sandpipers, it is too small to be considered a game bird, though often shot as such.

36. *PISOBIA MACULATA* (Vieillot). Pectoral Sandpiper. *Putilla*.

The Pectoral Sandpiper is a common fall migrant at Cartagena Lagoon, and is even abundant at times. Occasional birds are seen in the winter. They are common from August through October. In 1924 the first arrivals were noted on August 13. In 1922 a few were observed at Anegado Lagoon as late as April 1, and on April 27, 1924, I shot four from a flock of twenty feeding on the salt water mudflats near Cape Rojo Lighthouse, but I have no spring records from Cartagena Lagoon. There it feeds in the grass association, occasionally venturing into the dry open fields near the lagoon. It is particularly abundant in September. On September 17, 1924, there were at least 1,000 at the lagoon. All the birds collected were extremely fat.

The stomach contents of seven Pectoral Sandpipers collected at Cartagena Lagoon in August, September and October were examined. Animal matter comprised 67.6 per cent and vegetable matter 32.4 per cent. Noctuid larvæ constituted 51 per cent; noctuid adults 10 per cent; Sesban weevils (*Tyloderma sp.*), 16.1 per cent, Sphingid caterpillar 8.5 per cent; and Naucoridæ (*Pelocoris femoratus*), 2.9 per cent of the animal matter. Of the vegetable matter, 42.9 per cent was grass; 36 per cent was seeds of *Hymenachne amplexicaulis;* 5.6 per cent was seeds of Compositæ; 1.4 per cent *Naias guadeloupensis;* 1.4 per cent charcoal, and the remainder was rubbish.

The Pectoral Sandpiper lives exclusively in grassy land, and feeds largely on the Noctuid moths and their larvæ which abound in such places. Their food habits are entirely beneficial. They seldom associate with other species.

37. *PISOBIA FUSCICOLLIS* (Vieillot). White-rumped Sandpiper. *Putilla.*

The White-rumped Sandpiper is a rather uncommon fall migrant at Cartagena Lagoon. In 1924 it was noted from August 26 to October 20, and at times as many as thirty were noted in a day. The only previous record for the main Island of Porto Rico is a female collected by Bowdish (1902, p. 360) at the west end of the Island October 2, 1900. Wetmore (1916, p. 44) saw two on Culebrita Island April 15, 1912. At Cartagéna Lagoon the White-rumped Sandpipers did not flock together, but scattered among large flocks of Semipalmated Sandpipers, Yellowlegs, and other Sandpipers. In flight their form bore a strong resemblance to that of the Spotted Sandpiper. Their call notes were very distinctive, and I could recognize them by sound at a greater distance than by sight The call note is a sharp, metallic *prink, prink.* They feed mostly in the open-water association, where the water is very shallow. Occasionally they are flushed in the grass association.

Four White-rumped Sandpipers collected August 26 and September 17 had eaten 77.7 per cent of animal food and 22.3 per cent of vegetable matter. Fifty per cent of the animal matter consisted of Bloodworms; 25 per cent of Planorbis snails, and 5 per cent of *Corixa reticulata.* The vegetable matter consisted entirely of seeds, of which those of Compositæ formed 33.3 per cent; *Sesban emerus,* 30 per cent; and *Persicaria portoricensis,* 36.7 per cent. In addition to food the stomachs contained mineral matter (coarse red sand) forming 32.5 per cent of the stomach contents. This is a species of the mudflats and shallow-water areas and eats only such food as may be obtained there.

38. *PISOBIA MINUTILLA* (Vieillot). Least Sandpiper. *Putilla. Putilla chiquita.*

The Least Sandpiper is found at Cartagena Lagoon during the greater part of the time when the water is low enough to give it suitable feeding ground. It is a migrant from North America, but it is not long after the last spring migrants disappear before the first fall ones appear. In 1924 they were seen up to May 30, and appeared again July 5. It is very rare at the lagoon during the high-water period from November to March. D[illegible] the year it is never very common. Usually only three [illegible] seen in a day, occasionally as many as fifty. I have observed [illegible] much more commonly on the tidal mudflats near Cape Rojo [illegible] in April. At the lagoon they are almost exclusively a bird of the mudflats, alighting in the grass and sedge associations only when driven away from the mudflats. They usually occur in small flocks composed exclusively of their own species, although occasionally mingling to some extent with Semipalmated Sandpipers.

Ten stomachs collected in March, April, May, August and October were examined. These birds had eaten 80.9 per cent of animal matter and 19.1 per cent of vegetable matter The animal matter consisted entirely of insects and their larvæ All of them were either aquatic forms or terrestrial forms occurring commonly on the mudflats. The items which were not too much comminuted to be recognizable were: Dytiscid larvæ, 22 per cent of the animal matter; Carabid beetles (*Stenous* sp., a species inhabiting the mudflats), 20 per cent; very small aquatic Dipteroud larvæ, 25 per cent; aquatic Syrphid larvæ, 11 9 per cent, Carabid, probably *Stenous*, larvæ, 1.5 per cent The vegetable matter consisted entirely of seeds Those of *Sesban emerus* composed 50 per cent, those of an unidentified legume, 25 per cent, and of *Persicaria portoricensis*, 25 per cent of the total In addition to the food considerable gravel was found in the stomachs, forming 26 8 per cent of the total stomach contents.

39 *EREUNETES PUSILLUS* (Linnaeus). Semipalmated Sandpiper

Putilla.

The Semipalmated Sand piper is by far the most abundant shore bird at Cartagena Lagoon, though it occurs only as a fall migrant I have records from August 13 to October 20, 1924 During the latter part of August they are present in almost unbelievable numbers. I hardly dare estimate their numbers, but on August 26, when they were at the height of their abundance, I am sure that 100,000 would have been a low estimate of their numbers. They simply swarmed over the mudflats. On this date, although I was trying to avoid shooting them, I got sixteen while shooting other birds. They were so abundant that stray shots could not help killing numbers of them. On other days many were also unintentionally shot in the same manner In fact, all but four of the 36 that I collected were shot in this way. This species prefers the mudflats, but when they were so excessively abundant some were forced to feed in the sedge and

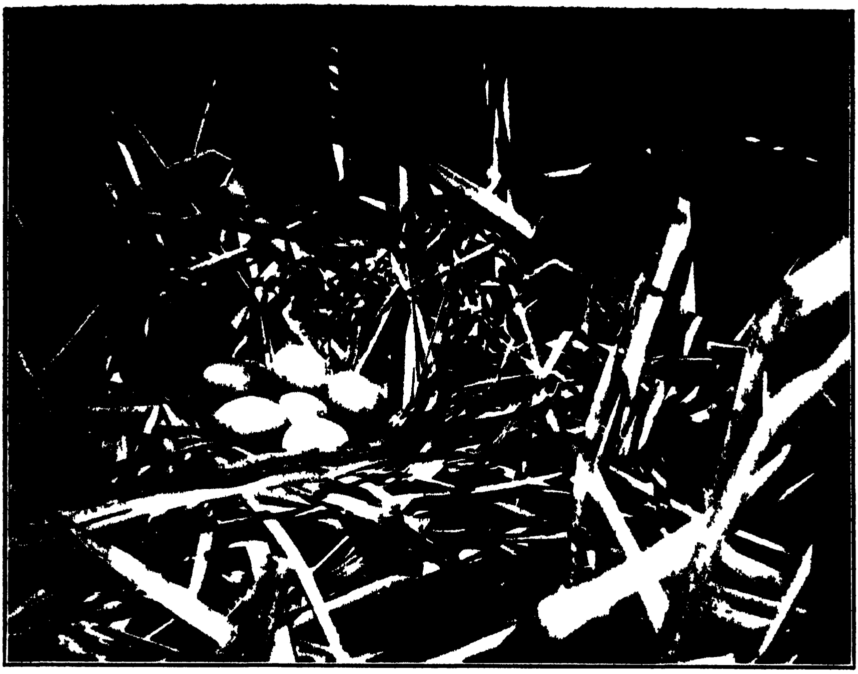


FIG 30—Nest and Eggs of Porto Rican Coot Cat tail Association September 20, 1924

FIG. 31—Nest and Eggs of Porto Rican Coot. Anchored to Sesban Bush,

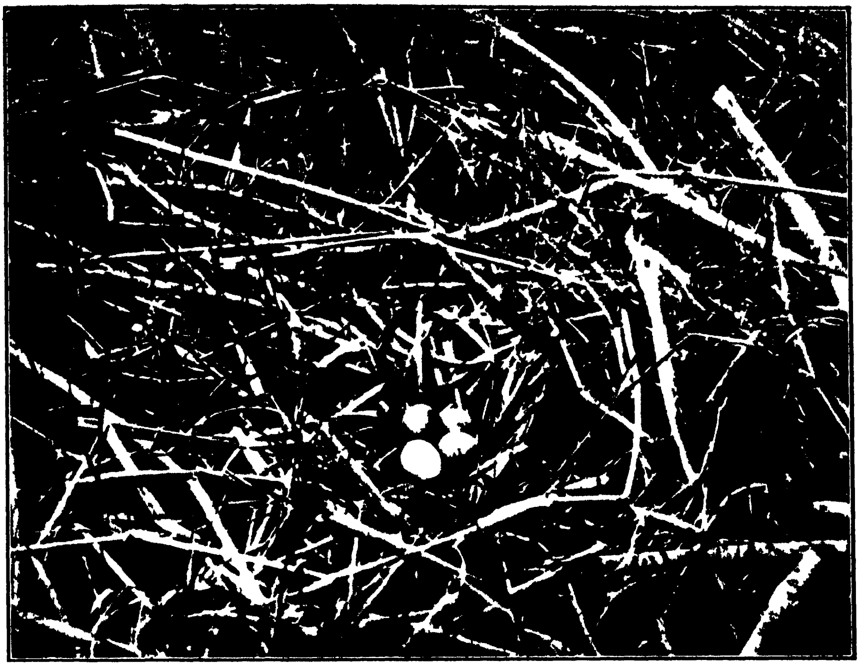


FIG 32.—Nest and Eggs of Black necked Stilt Sedge Association June 7, 1924

FIG. 33.—Nest (eggs robbed) of Black necked Stilt. Open Water Association. June 14, 1924

grass associations, and when the fall rains came a little later practically all of them were forced to the sedges and grasses and even to the canefields. But within a few days after this most of them left for parts unknown. I have occasionally observed this species in wet cane fields in other parts of the Island (Hormigueros and Boquerón) but its chosen habitat is the mudflats. Yellowlegs, Least, Stilt, and White-rumped Sandpipers frequently associate with them while feeding, but they were so much more abundant than any of the other species that they always formed the bulk of the flock. The mudflats are alive with bloodworms, and these form the principal food of the hordes of sandpipers that frequent them in August before the waters cover them too deeply. After that but few are eaten.

An examination of the contents of 36 stomachs taken in August and September shows that these birds had eaten 63.5 per cent of animal matter and 36.5 per cent of vegetable matter. Bloodworms formed 83.4 per cent of the animal matter, and over 90 per cent in the August stomachs. The remainder was composed of mudflat-inhabiting Carabid beetles (*Stenous sp*), 4.7 per cent; Hydrophilid larvæ 3.2 per cent; Dytiscid larvæ 1.9 per cent; *Coptocycla sp.* 1.8 per cent; aquatic Syrphid larvæ 0.45 per cent; Sesban weevils (*Tyloderma sp*), 0.27 per cent; Dytiscid adults, 0.23 per cent, and a little unidentifiable debris The vegetable matter consisted of seeds, of which the following were recognizable: Compositæ, (probably blown to lagoon from a distance), 54.6 per cent; Sesban emerus 10.5 per cent, *Persicaria portoricensis,* 3.8 per cent; *Hymenachne amplexicaulis,* 2.2 per cent; Crotalaria retusa, 0.3 per cent. In addition to the food these stomachs contained mineral matter (coarse sand) to the extent of 35.6 per cent of the stomach contents

The Semipalmated Sand piper is so small and so tame that it can scarcely be regarded as a game bird, and its insectivorous habits should give it a place on the protected list. When it occurs in canefields it doubtless eats many injurious insects.

40 *EREUNETES MAURI* (Cabanis). Western Sandpiper *Putilla.*

A female Western Sandpiper which I collected at Cartagena Lagoon on August 26, 1924, constitutes the first Porto Rican record for the species, and I have duly recorded it in the October, 1925, *Auk.* It was in a flock of Semipalmated Sandpipers feeding in shallow water. It was in almost full summer plumage. Its stomach contained 150 Bloodworms (90 per cent) and a Hydrophilid larva

(10 per cent). It had eaten some coarse sand, which formed 47 per cent of the stomach contents.

41. *TOTANUS MELANOLEUCUS* (Gmelin). Greater Yellowlegs. *Playante.*

The Greater Yellowlegs is a migrant from North America, but a few individuals apparently spend the summer at Cartagena Lagoon, as they were observed on every trip to the lagoon from May to September, and, in fact, on practically every visit throughout the year. It is not very abundant, and I have never observed over 20 in one day. It occurs in small flocks, mostly in the shallow parts of the open-water association, sometimes in the sedge and grass associations, with other sandpipers, especially the Stilt and Semipalmated Sandpipers and Lesser Yellowlegs, from which its larger size and characteristic notes distinguish it, especially when the two species occur near together.

Three birds, one collected in April and two in June, had eaten exclusively animal matter. The recognizable fragments were: Dragonfly naiads, 65.33 per cent; aquatic Hemiptera (*Belostoma* sp), 22 per cent; fish scales (*Poecilia vivipara*), 6.0 per cent; Dytiscid larvæ, 0.66 per cent. The food of these specimens was thus mostly such as would be obtained in the shallow open water, with the exception of a fleabeetle (*Haltica jamaicensis*), forming 1.3 per cent. This species is found abundantly in the sedge association. The Greater Yellowlegs is of neutral economic importance, as the fish are too small to be utilized as food. It is a game bird, and should receive protection from March to October. It is the only one of the sandpipers which is large enough to be of much value as a game bird.

42. *TOTANUS FLAVIPES* (Gmelin). Lesser Yellowlegs *Playante.*

The Lesser Yellowlegs is a common visitant from the north. As in the case of the Greater Yellow legs, some stay right through the summer, and there is never a day in the spring, summer and fall that it is not possible to observe some at Cartagena Lagoon. They become rather scarce at times of very high water in the winter, but they may then be observed abundantly at the saltponds on the nearby coast. At the lagoon they occur in flocks of from 2 to 100. They reach their greatest abundance early in October. On October 7 and 11, 1924, I observed over 1,000, and on other days shortly before and after these dates, from 500 to 800. Usually there are not over 100 present at once. They feed in the shallow open water, on the mudflats, and among the flooded grasses and sedges. They often associate with other sandpipers, especially the Greater Yellowlegs, Stilt, and Semipalmated Sandpipers. They are surprisingly tame while in Porto Rico, and it is slaughter, not sport, to shoot them. Sometimes the flocks are so densely packed that hunters kill as many as 20 at a single shot.

The stomach contents of nine Lesser Yellowlegs collected at Cartagena Lagoon in February, March, April, August, September and October were examined. Animal matter formed 99.22 per cent, and vegetable matter 0.78 per cent. Dytiscid larvæ formed 26.6 per cent of the animal matter, and Hydrophilid larvæ, 1.8 per cent; Bloodworms, 5.1 per cent; Planorbis snails, 5 per cent; Fleabeetles, 1.1 per cent; Hydrophilid adults, 3.1 per cent; Dytiscid adult, 0.7 per cent; grasshoppers, 0.22 per cent; Bupestrid beetle, 0.55 per cent; Lycosid spider, 0.55 per cent; Notonectidæ, 1 per cent; fish scales, 0.33 per cent; Carabid beetle (*Stenous* sp), 0.55 per cent, and other beetles 3.2 per cent. Many insects were too finely comminuted for identification. The vegetable matter was rubbish, and was probably taken in accidentally with the insects. Only one stomach contained any mineral matter. It consisted of a little red sand and formed only 1 per cent of the contents of that stomach. However, the stomachs of five birds collected at the saltponds at Boquerón on February 22, 1924, were entirely empty except for a few pieces of shell and a little sand, though they were collected in the afternoon. Incidentally, these birds, collected at a single shot, were all males. It is possible that birds of a sex flock together in the winter.

This is a neutral species as far as the agriculturist is concerned, as its food is obtained entirely in the marsh, but as it is classed as a game bird, and has some value as such, small as it is, it should receive at least as much protection as the Greater Yellowlegs.

43. *HELODROMAS SOLITARIUS SOLITARIUS* (Wilson). Solitary Sandpiper. *Putilla.*

The Solitary Sandpiper is an uncommon migrant at Cartagena Lagoon. I saw it on numerous occasions between August 30 and October 7, 1924, but never more than one at a time. It was seen on the mudflats, in the grass association, and in the damp canefields near the lagoon. I have also observed it in damp, newly plowed fields at Filial Amor, Cabo Rojo, and Boquerón in September and October. On September 20, 1924, ten were noted in a single field at Filial Amor. My only spring record for the Island is a single bird observed at Anegado Lagoon, March 4, 1922. They are not shy birds. When flushed they fly rapidly and utter their *tweet, tweet* call note.

The stomach of a female collected at Cartagena Lagoon September 9, 1924, contained nothing but one Hydrophilid beetle. It is probable that when feeding in canefields, as they frequently do, they eat many injurious insects. Two stomachs examined by Wetmore 1916, p. 42) contained only insects. The indications are that this is a useful species deserving protection. It is too small to be considered a game bird.

44. *CATOPTROPHORUS SEMIPALMATUS* subsp. Willet. *Playante.*

The Willet is an accidental visitant to Cartagena Lagoon. One was observed September 23, 1924, in the grassy area at the east end of the lagoon. On being alarmed it flew far away from the marsh towards the coast, where I have observed between 25 and 30 on two occasions in the mangrove swamps near Boquerón (February 22 and March 8, 1924). I also observed two on the tidal flats near Cape Rojo Lighthouse on April 27, 1924. Gundlach (1878, p. [illegible]9) found them at Boquerón and said he believed they nested on the Island. I collected two females at Boquerón on February 22, 1924. Their measurements do not check with those given by Ridgway for either *C. s. semipalmatus* or *C. s. inornatus.* The wing, bill and tarsus are as short or shorter than the extremes given for *C. s. semipalmatus,* while the tail is well within the limits given for *C. s. inornatus.* The measurements are given in the following table:

	C. s. longicaudis	C s semipalmatus		C s. inornatus		
	2 females, Boquerón, P R.	Female extremes Ridgway	Female ** Bahamas May	Female extremes, Ridgway	Female * N. Y., August	Female N Mex
Wing	172-191	175 191	199	209 5-220	212	215
Tail	81 81	66 5-74	74	74-88	82	85
Exposed culmen	49 54	58 5 59	55.5	63 0-65.0	61.5	65
Tarsus	47-55	51.5-58	54	66 5-70	69	68

* Female in winter plumage, collected at Ithaca, N Y. on August 8, 1921

** Female in summer plumage, collected May 5, 1902, on Andros Island, Bahamas Coll. L A Fuertes, No. 862.

It is possible that the Porto Rican birds represent a resident subspecies differing from mainland birds. If such proves to be the case I suggest the subspecific name *longicaudis* for the Porto Rican bird, with a female collected at Boquerón, February 22, 1924 (Cornell University Collection No. 2326), as the type.

The stomach contents of the two birds collected at Boquerón were examined. One contained nothing but a crab (*Hippa* sp), and the other only a fiddler crab (*Uca pugnax rapax*).

45. *ACTITIS MACULARIA* (Linnaeus). Spotted Sandpiper. *Putilla.*

The Spotted Sandpiper is a tolerably common winter visitant to Cartagena Lagoon. In 1924 the last spring birds were noted May 23, and the first fall arrivals August 13. This is a bird frequenting firmer ground than the other sandpipers. It is seldom observed feeding in the shallow water or on the mudflats, but prefers the firmer south shore at the edge of the Varronia association, and is also found at the edge of the open-fields association, and frequently right in the canefields. The other sandpipers seldom alight on elevated perches, but this one often perches on fence posts, keeping up its characteristic teetering all the while. It is also frequently found on the sea beach and along the smaller inland streams. It is the most universally distributed sandpiper on the Island.

Two birds collected February 15 and September 9 at Cartagena Lagoon had eaten entirely animal matter. Carabid beetles (*Stenous* sp) formed 58.5 per cent; engraver beetles (*Xyleborus* sp), 20 per cent; down feathers (probably its own), 7.5 per cent, and miscellaneous insects, mostly Coleoptera, 15 per cent. Wetmore (1916, p. 41) found mole crickets forming 10.78 per cent of the food in 9 stomachs, and undoubtedly those individuals that feed in canefields consume many of them. Many crustaceans were also found in these stomachs.

The Spotted Sandpiper feeds in the fields more than any of the other sandpipers, and it is present during the greater part of the year, so its beneficial possibilities are great and should win protection for it.

46. *CHARADRIUS DOMINICUS DOMINICUS* (Müller). Golden Plover. *Playero.*

The Golden Plover is probably a rare migrant at Cartagena Lagoon. I have no positive records for it, but on February 15, 1924, a flock of five Plovers flew over the lagoon which I believed to be of this species. Struthers (1923 p. 473) collected one from a flock of six at Anegado Lagoon on November 4, 1921, and Wetmore (1916, p. 40) saw one near the mouth of the Río Mameyes on February 16, 1912. These are the only recent records for the Island.

47. *OXYECHUS VOCIFERUS RUBIDUS* (Riley). **West Indian Killdeer.** ***Putilla.***

The West Indian Killdeer, which is similar to *O. v. vociferus*, but smaller and darker colored, is a permanent resident at Cartagena Lagoon. It is common during most of the year, but decidedly uncommon during the high-water period from November to February. In fact I have never seen them at the lagoon in December, and only once in January. During these months they are feeding in the drier parts of the Island, and wander a good deal. They may then be found farther inland than usual. In December 1923 they were quite common on the then dry bottom of Anegado Lagoon.

While at the lagoon the West Indian Killdeer prefers the grass association, but is not uncommonly found in the sedge association and on the mudflats, and is common in the nearby canefields, and is particularly fond of newly plowed fields. It is an extremely noisy bird, particularly in the breeding season. Many a time when I have been stalking some rare or shy bird have I felt a keen desire to wring the necks of the loud-mouthed killdeers that stalked just ahead of me screeming as loudly as they could and scaring away every bird in the region. They have a habit of running very rapidly for a short distance, then stopping abruptly and looking around, and then speeding on for a few more feet. They are apparently seminocturnal, as their cries may be heard for an hour or two after sunset and for about an hour before sunrise.

On one occasion (June 18, 1924) I had a rather unusual experience with a West Indian Killdeer. While I was walking through a rather thick growth of sedges one ran out from almost underfoot and squatted, or it might be said "froze" on the ground a few feet away. I slowly approached it until I actually touched it with my gun barrel, but yet it did not fly. Then I moved my hand slowly towards it, grabbed it, and picked it up to examine it. Its tail feathers were worn, a possible indication of incubation, but a careful search revealed no nest or young nearby. On being released the bird flew away in perfectly normal fashion.

The West Indian Killdeer breeds in the fields near Cartagena Lagoon, but I have not been fortunate enough to discover any nests. It apparently nests in the grassy regions, particularly in the open-fields association. Country people living nearby report having found nests on the ground with three to five eggs, usually four. The nesting season apparently extends from February to June. A female collected February 6, 1924, contained well-developed ovules. On

May 27, 1924, one practised deception to a remarkable degree, evidently in trying to lead me away from its nest. Three times it flew a short distance ahead of me and then settled down on the ground and went through the motions of a hen settling down on her nest and turning the eggs under her.

The stomach contents of four birds collected at Cartagena Lagoon in February, March, and September were examined. Animal matter formed 98 per cent of the contents, and vegetable matter 2 per cent. In addition, mineral matter (sand and gravel) to the extent of 7.73 per cent of the stomach contents was found. Of the animal matter, Hydrophilid larvæ formed 23 per cent; Dytiscid larvæ, 6.77 per cent; Maybeetle (*Phyllophaga vandinei*), 20.5 per cent; Carabid beetles (*Stenous* sp.), 18.8 per cent; Noctuid caterpillars (35, forming 97 per cent of the contents of 1 stomach), 24.27 per cent; Sesban weevils (*Tyloderma* sp.), 1.75 per cent; and miscellaneous insect matter, 4.91 per cent. The vegetable matter consisted of two seeds (one of them a Composite) and a little rubbish.

The West Indian Killdeer is an exceptionally useful bird, as it regularly inhabits canefields, especially when newly plowed, and its food habits are almost entirely benefical. Wetmore (1916, p. 39) found that mole crickets formed 14.42 per cent of the food in 20 stomachs, and beetles, many of them noxious, formed over 30 per cent. At the lagoon this species inhabits the drier, firmer parts, especially the grass association. Although small, it is often considered a game bird, but should receive full protection on account of its great value to the agriculturist.

48. *PAGOLLA WILSONIA WILSONIA* (Ord.) Wilson's Plover. *Putilla. Playero.*

Wilson's Plover is only a straggler to Cartagena Lagoon, though it is found on tidal mudflats at all times of the year and almost undoubtedly breeds on the Island. The only record I have for this species at the lagoon is that of a female with very small ovary which I collected on June 3, 1924. It was feeding on mudflats which were then covered with very shallow water. Its stomach contained 93 per cent of animal matter and 7 per cent of vegetable matter, in addition to some white sand, which formed three per cent of the total contents. All the identifiable animal matter consisted of Dytiscid adults (5 per cent) and six Dytiscid larvæ (92 per cent). The vegetable matter was rubbish.

Near Cape Rojo Lighthouse I observed 64 of these birds on April

27, 1924. Most of them were on the tidal mudflats, but a few were on the sandy beach. Two males, with much enlarged testes indicating breeding, were collected on that date. Their stomachs contained 90 per cent animal matter and 10 per cent vegetable matter. Fragments of a small fish formed 47.5 per cent, a small hermit crab 50 per cent, and fragments of a beetle 2.5 per cent of the animal matter. The vegetable matter was entirely composed of pieces of a fine grass-like alga.

This species is of little economic importance, as it is quite uncommon and is a maritime species, only occasionally straggling to regions away from the coast.

49. *ZENAIDA ZENAIDA LUCIDA* (Noble). Porto Rican Zenaida Dove. *Tórtola.*

The Zenaida Dove is common in the vicinity of Cartagena Lagoon, and frequently comes to the marsh, though not very often in the winter months Although most of these birds breed elsewhere, a few nest in the marsh, and others go there for food and water. The few that visit the immediate vicinity of the lagoon in winter are found almost exclusively in the Varronia association, where they appear to be feeding.

The Zenaida Dove is very wary and difficult to approach It flushes with a loud clapping of the wings and flies a long distance before alighting. It quite closely resembles the Mourning Dove while walking on the ground, and its notes are even more similar It feeds upon the ground, but upon being flushed alights in trees, and at other times it can often be found resting in trees It is a bird of the cultivated lowlands, mangrove swamps, and the lower foothills, never being found in the higher hills It feeds singly or in small flocks. On one occasion (February 25, 1922) near Mayagüez I flushed a flock of twenty, but that is very unusual.

At Cartagena Lagoon these birds feed chiefly in the Varronias in winter, but in the summer many feed in the grass and sedge associations left dry by the receding waters of the lagoon. The usual nesting place of the Zenaida Dove is in trees. I found such a nest on Tinaja Hill, near the lagoon, on May 6, 1924. It was a loosely constructed platform built on horizontal branch of a scrubby tree at about five feet from the ground, on a wild precipitous slope. At the lagoon a few of these doves forsake their usual nesting sites and nest in the cat-tails. I found two such nests in 1924. The first was a crude platform of twigs on some bent cat-tail leaves in a dense

FIG 34.—Nest and Eggs of Black necked Stilt Sedge Association June 14, 1924

FIG 35.—Nest and Eggs of Black-necked Stilt Mudflat Island, Open Water Association June 14, 1924

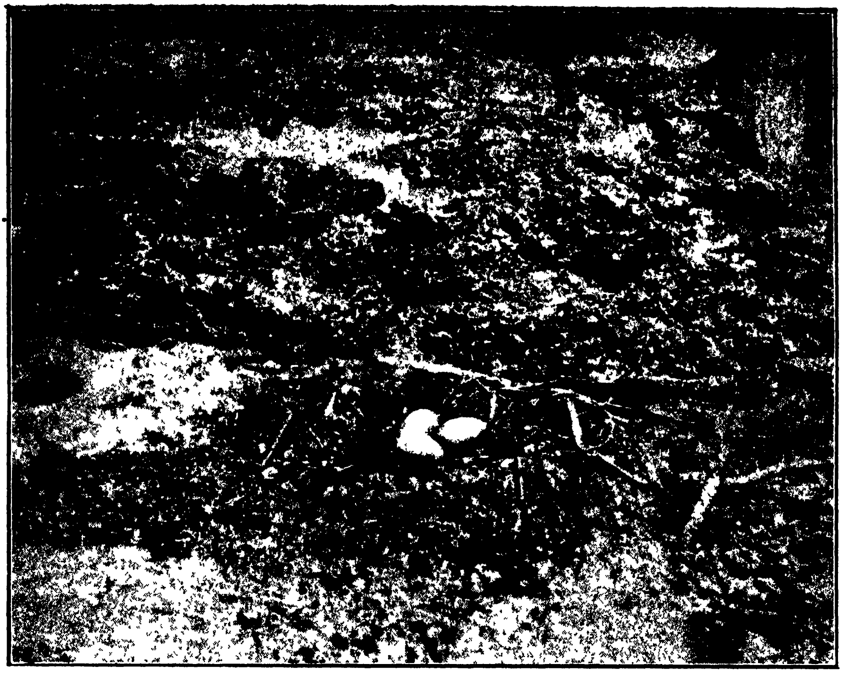


FIG. 36.—Nest and Eggs of Black-necked Stilt. Mudflats. June 14, 1924

[illegible]

clump on Las Casitas. It was three feet above the water, which was two feet deep at that place. On May 13 it contained two white eggs, but the nest was so frail it fell to pieces before the eggs had time to hatch. The second nest was built of dry cat-tail leaves and placed in the cat-tails at a height of four feet from the water, which was two inches deep at that time. When I found it on May 27 it contained two egg shells from which the young had hatched but the young birds were nowhere to be seen.

This species is probably preyed upon to some extent by the Mongoose, although its nesting habits make it more immune to attack than the Ground Dove. The Zenaida Dove is one of the most sought-for game birds on the Island, and justly so, as its meat is of good flavor and it is so wary that one has to be an expert marksman to obtain many. But it has a disadvantage in that it frequently flies long distance after being shot before it falls, making the recovery of the birds shot very difficult. Often but a small per centage of the birds killed are recovered, especially when one is hunting in rough country. The few that I have shot were lost in this manner, so I can say nothing at first hand about the stomach contents of this species. Field observations, however, indicate that *Persicaria* seeds are freely eaten. Wetmore (1916, p. 52) found that this species is almost entirely vegetarian in its diet. He found that a great variety of fruits and seeds were eaten, among which were Moral (*Cordia* sp.), several species of grass, and *Polygonum*.

This is a species which visits the lagoon for food, water and shelter, yet it is not preeminently a bird of the lagoon. It is an adaptable species, and apparently some individuals, becoming crowded out of their more natural habitat, and finding a plentiful supply of food and nesting sites of a fashion at the lagoon, decide to stay there to breed. It is an admirable game bird, and should be protected at least from February 15 to October 15 to give the birds a chance to rear their young in safety.

50. *CHAEMEPELIA PASSERINA TROCHILA* (Bonaparte). Porto Rican Ground Dove. *Rolita*, *Rola*.

The Porto Rican Ground Dove is an abundant species in the immediate vicinity of Cartagena Lagoon, and frequently enters the marsh proper, particularly at periods of low water, to feed. It never nests in the marsh. When the water is low, it feeds in all the marsh association except the open-water and cat-tail associations, and at times of high water it forages in all parts of the marsh where wading *or swimming is not necessary.* **This little dove is generally abundant throughout the lowland open country in Porto Rico, and is also very common in the lower foothills, particularly those that are covered with brush. It occurs very commonly in canefields, even after the cane is full grown. It feeds exclusively upon the ground, but sometimes alights in trees. At many times of the year, but especially in December, a chorus of mournful *coos* may be heard from the males, which perch in trees to utter these notes. When feeding on the ground they often try to flee from an intruder by walking rapidly away, but if approached too closely they suddenly take flight. When in flight the red under surfaces of the wings are conspicuously exhibited.**

These little doves are found in small flocks during the greater part of the year, but during the period from March to June, which covers the greater part of the breeding season, they are usually observed singly or in pairs. The usual nesting site in Porto Rico is in trees or shrubs. This has been believed by Wetmore (1916, p. 50) and Bowdish (1902, p. 361) to be in order to escape the Mongoose, but I doubt if this is the reason, as Gundlach, writing in 1878 (p. 349), before the Mongoose was introduced, says that they nest in coffee, lime and plantain trees, among shoots of trees, among parasitic plants, and above the doorways of country houses, and does not even mention finding any nests on the ground. Nevertheless this species does at least occasionally nest on the ground, and I am inclined to believe that they do so quite commonly in the vicinity of Cartagena Lagoon, though I have actually found only one such nest. This was on Tinaja Hill, about two-thirds of the way to the summit. The nest was built of fine grasses and placed upon the ground under the shelter of a small rock. It was found by flushing the female. On May 28, 1922, it contained two fresh white eggs.

The Mongoose is an important enemy of this species as it feeds and sometimes nests upon the ground. Men sometimes hunt them, as their flesh is said to be excellent, but they are small and usually larger game is sought.

Three birds collected at Cartagena Lagoon in May and September were entirely vegetarian in their diet; in fact their food consisted entirely of seeds. Among these were those of *Persicaria portoricensis* (33 per cent); Cyperaceæ, 26 per cent; *Hymenachne amplexicaulis*, 2 per cent, and of *Sesban emerus*, 7 per cent. The stomach contents of two birds collected near the then dry Guánica Lagoon on October 3, 1924, were also examined. In these the only identifiable seeds were *Crotalaria* sp. (1.5 per cent), *Panicum* sp. (15 per cent) and *Polygonum* sp. (10 per cent). These birds also eat considerable gravel, but this formed only 4 per cent of the contents of the five stomachs examined.

To sum up, the Porto Rican Ground Dove is an abundant species, found everywhere in the open lowlands of Porto Rico. It frequents the drier parts of the marsh to gain its share of the abundance of food which is found there, but it chooses other places to nest. It is sometimes considered a game bird, but it is so small and so useful that it should be placed upon the protected list.

51. *CATHARTES AURA AURA* (Linnaeus). Southern Turkey Vulture. *Aura. Aura tiñosa.*

The Southern Turkey Vulture is said to have been introduced in Porto Rico from Cuba by the Spanish government. It is restricted in its distribution there to the southwestern corner of the Island, having been observed from Ponce to Añasco, but it is commonly observed only in the region from Boquerón to Yauco, which includes Cartagena Lagoon. Seventeen is the most that I have been able to count circling around any one dead animal, and as their range is so restricted this probably represents the greater part of the individuals on the Island. Their number are said (Wetmore, 1916, p. 30) not to have increased or decreased materially nor to have increased their range in many years. None nest in the immediate vicinity of the lagoon, but they often visit the marsh to pick the bones of dead animals, prticularly of Coots, ducks, gallinules, etc., that have been shot but not recovered by the hunters. They are not particularly shy, and may often be approached quite closely while feeding or resting upon the ground.

The Turkey Vulture apparently has no enemies but the Mongoose. The country people realize that they are useful, and that their flesh is not edible, so they are seldom molested.

52. *CIRCUS HUDSONIUS* (Linnaeus). Marsh Hawk. *Gavilán.*

The Marsh Hawk is a rare winter visitor to Cartagena Lagoon. An immature bird was observed there on frequent occasions between November 30 and December 27, 1923. This constitutes the first record for the Island, which I am publishing in the October, 1925, *Auk*. It was hawking over the grassy regions in typical Marsh Hawk style. On December 22 two were noted.

53. *BUTEO BOREALIS* subsp. Red-tailed Hawk. *Guaraguao*. *Lechuza*.

The Red-tailed Hawk, though not properly speaking a resident of Cartagena Lagoon, is often seen flying over it, and sometimes visits it in quest of food. One pair breeds on Tinaja Hill, and sometimes descends to the marsh to obtain some of the abundant animal life which is to be found there.

This is not a rare species in most parts of the Island, and is seen most frequently in the foothill region. I have observed it in the hills between Arecibo and Utuado, at Mayagüez, Guánica and La Plata. I have never observed more than two together. Its wild scream is a signal for the country people to call their chickens home, for it is said to eat many chickens. I have no doubt that some are taken, as the custom of allowing all poultry to run loose exposes them to attack. On April 26, 1924, near Guánica I observed a *guaraguao* swoop down and strike a small hen in the field, but we gave it a scare and it dropped the hen, which half limped and half flew towards shelter. A bird observed at Cartagena Lagoon on February 6, 1924, had a rat in its claws. Stomachs examined by Bowdish (1902, p. 361) and Wetmore (1916, p. 33) contained nothing but rat remains. An immature bird obtained at Mayagüez September 18, 1924, was apparently a sick bird. It was wounded by throwing a rock at it. Its stomach contained one brown feather which appeared to be one of its own, and a lot of grass, in addition to some coarse gravel, which formed 6 per cent of the contents. The evidence shows that this bird is often if not usually beneficial, so only those birds which form the habit of eating poultry should be destroyed. .

The adults of this species are known to the country people as *guaraguao,* and immature birds as *lechuza.* The subspecific status of the Porto Rican form is uncertain.

54. *FALCO PEREGRINUS ANATUM* (Bonaparte). Duck Hawk.
Falcón grande.

The Duck Hawk is an irregular winter visitant at Cartagena Lagoon. A bird in the plumage indicated as first year in the plates of the Birds of New York spent the winter of 1921–22 at the lagoon. My latest record was March 22, 1922, though I observed one at Anegado Lagoon on April 1, 1922. During the winter of 1923–24 none were seen, but one arrived September 30, 1924, and was observed regularly until I left the latter part of October.

When in pursuit of its prey this species is fearless of man. At the lagoon it seldom attacks any swimming waterfowl, but waits until they have been flushed and then pursues them at tremendous speed, often whizzing past the man who has flushed them like a catapult in its haste to obtain its prey. It is particularly fond of Allen's Ruddy Ducks and Porto Rican Coots, but they show remarkable ability in dropping to the water and diving when pursued. I have also observed this Hawk pursue some of the larger shore birds, especially the Black Necked Stilt and Lesser Yellowlegs. I once witnessed an exciting race for life on the part of a Black Necked Stilt. The Stilt kept ahead for quite awhile, but the Hawk was steadily gaining on it. Just as it seemed as though its talons would sink into the unfortunate Stilt, a dash into some thick brush saved its life, and the Hawk flew away disappointed. When a Duck Hawk flies near a flock of Little Blue Herons they scatter in a hurry. Despite their large size they fear the "Noble Peregrine". In Porto Rico the Duck Hawk has no enemy but man. It is a destructive species, but fortunately it is not abundant enough to do serious damage. However, it should not be protected.

55. *FALCO COLUMBARIUS COLUMBARIUS* (Linnaeus). Pigeon Hawk. *Gavilán. Lechuza.*

The Pigeon Hawk is a regular winter visitant to Cartagena Lagoon. Two birds wintered there in 1921–22, two in 1923–24, and two appeared in the fall of 1924. I have also observed this species at various other localities on the Island. In my notes I find records for Quebradillas, April 12, 1922; Sabana Grande, April 25, 1924; and La Plata December 14, 1923, and March 29, 1924. At Cartagena Lagoon my latest spring record is April 18, 1924, and my earliest fall record October 20, 1924.

At the lagoon it was usually a rather shy species, seldom permitting of close approach. It hunted mostly over the grassy areas, occasionally making tours over the open water and other parts of the marsh. Its favorite perching place was on some posts which supported a barbed-wire fence at the north edge of the lagoon. On one occasion (October 20, 1924) a Pigeon Hawk went through a rather surprising performance. Two birds were apparently fighting for feeding rights, pursuing each other on the wing. Then one of the birds alighted in a Jobo tree south of the lagoon, and the other flew off. As I approached the bird in the tree, much to my surprise it flew towards me, and alighted *on the ground* eight feet in front of me, and flapped its wings as though feigning injury. A boy who was near then hit it with a pebble and it flew off.

A male collected April 8, 1924, had eaten exclusively animal matter. Two bright red and yellow dragonflies and six other dragonflies formed 73 per cent, a damselfly naiad 12 per cent, and the feathers of a small bird, apparently *Petrochelidon fulva poecilloma,* 15 per cent. In the field I observed one chasing a Porto Rican Grackle, but it escaped. The Pigeon Hawk is another injurious species by reason of its destruction of small birds and dragonflies, and does not deserve protection, though it is not abundant enough to do very great damage.

56. *CERCHNEIS SPARVERIA LOQUACULA* (Riley). Porto Rican Sparrow Hawk. *Falcón.*

The Porto Rican Sparrow Hawk, although a common resident in most of the coastal lowlands of Porto Rico, is a rare visitor to Cartagena Lagoon. In 1923–24 I observed it on just six occasions, mostly in the winter months. When at the lagoon it more often occurs in the open-fields and Varronia associations than in the marsh proper. These Hawks occupy commanding perches from which they scan the nearby country for prey. Field observations indicate that this consists largely of grasshoppers and lizards. I once observed one devouring an *Ameiva exul* so large that it could be swallowed only with great difficulty. It was being scolded the while by a *Chlorostilbon maugaei.* These diminutive hummers, smaller than the North American Ruby Throat, often scold and pursue Sparrow Hawks, either alone or accompanied by other birds, notably the Gray Kingbird and the Yellow-shouldered Black-bird. On March 9, 1924, at Mayagüez, I observed the mating of the Porto Rico Sparrow Hawk. The male pursued the female for a short distance, and upon capturing her mating took place.

Only one stomach, that of a female collected near Cartagena Lagoon on October 10, 1924, was examined. It was nearly empty, containing only a small wad of mouse fur and some fragments of what was probably a centipede. Wetmore (1916, p. 31) found that many mole crickets and other Orthoptera were eaten, and these, together with House Mice, offset the damage done by eating many lizards and a few small birds, so that on the whole they are of somewhat neutral value. Individuals living near canefields where mice and mole crickets abound are of more value, and they should be encouraged to take up their bode there by providing conspicuous high perches from which they can scan the fields for prey.

57. *PANDION HALIAETUS CAROLINENSIS* (Gmelin). Osprey. *Aguila.*

The Osprey is a rare visitor to Cartagena Lagoon. I have observed one flying over the lagoon on two occasions, March 11, and September 27, 1924. On the latter occasion it uttered its familiar whistling cry. The only other record for Porto Rico I have is of two birds observed over Boquerón Bay on March 22, 1922.

58. *GYMNASIO NUDIPES* (Daudin). Bare-legged Owl. *Múcaro*

Although I have not personally recorded the Bare-legged Owl from Cartagena Lagoon, probably largely because I have not been able to be there at night, I am including it in my list because the country people tell me they sometimes hear it at night. It is a common resident over most of Porto Rico, and might even be classed as abundant in certain regions, particularly in the mountain coffee *fincas*. It is very common around Mayagüez, and when camping on Montuoso Mountain in April, 1922, dozens could be heard calling in all directions among the mountain coffee *fincas*. Its call is a tremulous trill, more tremulous and more rapidly trilled than that of the Screech Owl. It also has a merry, chattering sound which is uttered more frequently during the winter months than the trill. These owls are more vocal on moonlight nights than on dark ones, and they may be then be heard thoroughout the night, whilst on dark nights they are usually only heard for a short time after dusk and for a short time before dawn. On one occasion (May 18, 1924) at Mayagüez (to which locality most of my notes on this species refer) I kept track of the calls heard towards morning to ascertain at what minute the last calls would be uttered. The last one was heard at 5 :57, just before the sun rose with charasteristic tropical suddenness. On moonlight nights these little owls may sometimes be observed very clearly by placing one's self so that the owl is between himself and the moon. One of my most vivid memories of Porto Rican nights is of watching a *múcaro* perched on the branch of a eucalyptus tree, with the moon directly behind it, preening its fink feathers. Its long, bare legs were very conspicuous. Once it flew down to the ground with swift, noiseless flight, and apparently picked up some insect. They also perch at times upon the rolled-up new leaves of banana trees. There normally stand up vertically, but when the owl alights on them they bend to a horizontal position.

In the latter part of the winter of 1922 my brother was presented with a full-sized but still downy young *múcaro* which was captured on the University campus at Mayagüez. It was blind in one eye. He kept it as a pet for several months, feeding it meat and insects. It would eat cooked beef ravenously, pulling it to pieces with beak and claws before swallowing it. But its favorite food was cockroaches, which could be obtained in great numbers without difficulty. He tried to give it its liberty several times, but probably on account of its blind eye it could fly only in circles, and always returned When we left the Island it was given to some neighbors, but they could not get it to eat anything, so it did not live long.

The country people believe that *múcaros* are injurious by reason of consuming many coffee berries, but there is no evidence to support this theory, and there is much evidence that it is not so. No one has ever seen one actually eating coffee berries, nor have any been found in the contents of stomachs examined. Dr. Wetmore (1916, p. 67) tried to starve some captive birds into eating coffee berries. They could not be induced to eat them, but on being offered animal food they promptly ate it. This experiment was repeated by Miss Rosario Brito of Mayagüez, with similar results.

Two birds were collected at Mayagüez, one in December and one October 3, 1924. The stomach of the December bird was unfortunately lost That of the October bird contained exclusively insects Those identified were a huge rat-tailed maggot forming 15 per cent; a large Katydid, 25 per cent; two sugar cane root borers (*Diaprepes spengleri*), 8 per cent; 2 large green caterpillars, 5 per cent; 4 Noctuid moths, 1 per cent, and 1 small Locustid, 1 per cent.

The Bare-legged Owl is a useful species due to its fondness for insects, and is of exceptional value because it is adapted to obtain those insects that are nocturnal in habit. On this account it should receive full protection.

59. *CROTOPHAGA ANI* (Linnaeus). Ani. *Judío.*

The Ani is a common resident species at Cartagena Lagoon, and, in fact, throughout most of the Island. It feeds regularly in all the plant associations of the lagoon except the open-water association, and nests in the Bamboos and the higher trees of the Varronia association. It is always found in flocks, usually of from 6 to 15, and always feeds on or near the ground. When alarmed it flies to a shrub or low tree and examines the intruder, uttering its querulous notes. The flight is low, and seldom of continued duration. The

FIG. 38.—Semipalmated Sandpipers. August 26, 1924

FIG. 39.—Nest and Eggs of Porto Rican Ground Dove. Tinaja Hill. May 28, 1922

FIG. 40.—Downy Young Bare-legged Owl May 1922

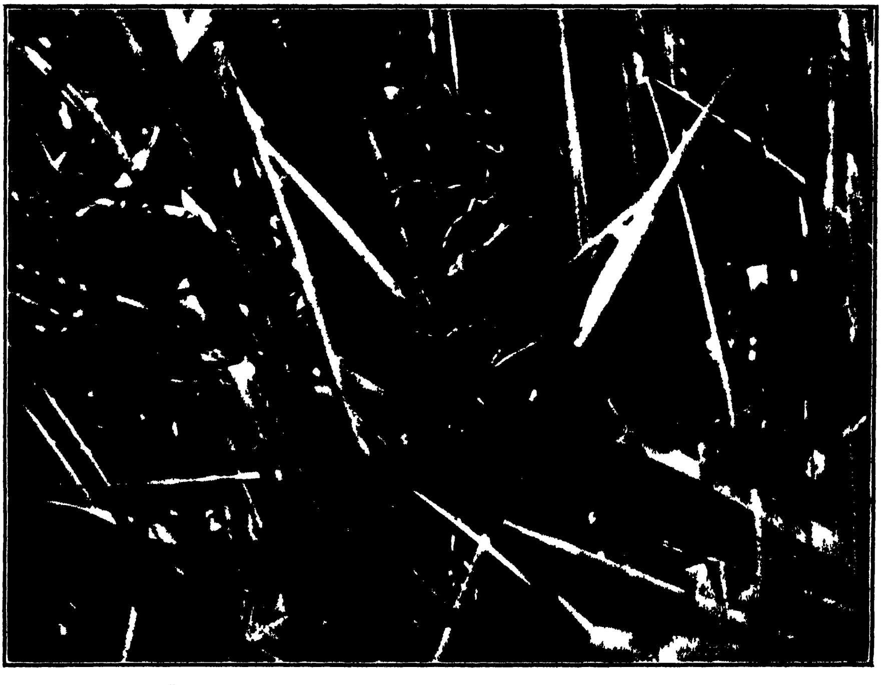


FIG. 41.—Nest of Porto Rican Grackle in Cat-tails

Ani is quite helpless in a strong wind. Anis usually seem quite peaceful, but once (May 23, 1924) I observed two birds fighting on the ground. With ruffled feathers they would advance to meet each other, emitting guttural *kr-rick* sounds. This kept up until one gave the other a sound jab and caused it to fly away.

The Ani apparently has no well-defined breeding season, as birds may be found breeding at all times of the year. Near the lagoon most of the nests are built in bamboos. They are bulky affairs constructed of sticks and bamboo leaves. From December 4 to 11, 1923, I watched a nest in construction about 12 feet from the ground in an isolated bamboo clump in the open-fields association about 100 yards north of the lagoon waters. A flock of thirteen Anis were interested in it. The bamboo leaves used for construction were still green Many individuals apparently assisted in the work, yet it proceeded slowly, as they were not very diligent workers. Unfortunately the birds deserted after the first time that I casually climbed up to the nest, so I did not have the opportunity of observing the eggs and young. When the nest was approached the whole flock would gather around and utter complaining calls. I am told by reliable observers that as many as twenty eggs are found in a nest.

On September 30, 1924, I found a young Ani on the ground under some bamboos. It was unable to fly. The wing and tail quills were about half grown. The rest of its plumage consisted of black and white natal down, giving the bird a somewhat ludicrous resemblance to an immature Barred Rock fowl. A large area in the middle of the breast was bare. A flock of seven or eight adults in the bamboos overhead showed great solicitude for its welfare, flying around anxiously and "yelping" until I was some distance away. Many juvenile birds were noted in the Varronias during the summer and fall months. A juvenile male 9.25 inches long collected there October 7, 1924, had not quite finished acquiring its first plumage; a tittle natal down was left. The wing quills were barely long enough to permit it to fly. Despite the small size of the bird, its oil gland was fully as large as that of adult birds.

The Ani feeds so extensively upon the ground that undoubtedly some are eaten by the Mongoose, but they are very quick to observe danger, and if one bird in the flock gives the alarm note the rest all fly immediately, so they seem to be able to maintain their own pretty well against the Mongoose. Their flesh has a peculiar odor, so they are not sought by hunters as food. Altogether, their enemies are few, so they flourish and are abundant.

The Ani eats almost anything living that comes its way, although it is particularly fond of Orthoptera. In addition, it does not refuse fleshy fruits it they are conveniently obtained. In the field Anis may often be observed eating insects of many kinds and occasionally fruits. I have even observed one swallowing a large mouse entire. It alighted on a wire fence to do it, and had to strain and gulp considerably before the mouse slipped down.

Seven Anis were collected at Cartagena Lagoon and their stomach contents examined. Animal matter formed 99.57 per cent of the food, and the remaining 0.43 per cent consisted of the seeds of fleshy fruits. Twenty-five Mole Cricket nymphs were found in two stomachs, and formed 19.1 per cent of the animal matter. Grasshoppers formed 19.3 per cent and cockroaches 17.9 per cent. Other items found in smaller quantity were:

Naucoridae (*Pelocoris femoratus*)	0.57 per cent
Corixidae (*Corixa reticulata*)	0.14 per cent
Beetle (*Ceratoma ruficornis*)	0.14 per cent
Earwig	0.14 per cent
White flower spider	0.28 per cent
Cave Crickets (*Rhadiphorinae*)	0.71 per cent
Fleabeetles (*Disonycha laevigata*)	0.14 per cent
Fleabeetles (*Cryptocephalus tristiculis*)	0.28 per cent
Fleabeetles (*Oedionychus cyanipennis*)	0.14 per cent
Smooth green caterpillars	8.85 per cent
Lepidopterous pupae	0.71 per cent
Dytiscid larva	1.4 per cent
Blue damselflies	1.4 per cent
Metamasius hemipterus	0.28 per cent
Wasp	0.28 per cent
Sesban weevils (*Tyloderma* sp.)	0.14 per cent
Calosoma beetle	0.28 per cent
Other Carabidae	1.4 per cent
Sugar cane root borers (*Diaprepes spengleri*)	0.71 per cent
Dragonfly naiads	2.57 per cent
Noctuid moths	4.7 per cent
Black feathers (probably its own)	0.71 per cent
Hydrophilid larvae	0.47 per cent
Spider (*Aranea* sp.)	0.47 per cent
Noctuid caterpillars	1.4 per cent
Ambush bug	0.71 per cent
Spider	0.71 per cent

The Ani is thus shown to be a rather omnivorous eater as far as animal matter is concerned, and it is attracted to the lagoon by an abundance of food rather than by any special love of marsh conditions. It is only slightly more abundant at the lagoon than in the Island in general. It is highly beneficial in its food habits. It is a valuable species, and it is fortunate indeed for the agriculturist that it is as abundant as it is. Would that it were even more abundant.

60. *COCCYZUS MINOR NESIOTES* (Cabanis). Mangrove Cuckoo. *Pájaro Bobo.*

The Mangrove Cuckoo is a rare bird at Cartagena Lagoon, where I have observed it only in the Varronia association. It is a resident species, not very common on any part of the Island. I have observed it most frequently in the vicinity of Mayagüez, where it is not unusual to see and hear it in the coffee *fincas*. The call notes are similar to those of the Yellow-billed Cuckoo. I collected a male with much enlarged testes in a coffee *finca* near Mayagüez on June 24, 1924. Its stomach contained two sugar-cane root-borers, (*Diaprepes spengleri*) and a little debris. One observed in the field was catching moths in an orange grove. Dr. Wetmore (1916, p. 57) found this to be one of the most beneficial birds on the island on account of its propensities for devouring Coleoptera and injurious caterpillars It is unfortunate that it is not more abundant.

61. *TODUS MEXICANUS* (Lesson). Porto Rican Tody *San Pedrito. Medio Peso.*

The Tody is never found in the marsh proper, but one pair lives in the Bamboo association, and I have observed a number on Tinaja Hill. It is common over most of the Island, particularly so in the coffee *fincas*. Todies are very tame birds, and I believe it would be possible to catch them in an insect net. They are usually found in the undergrowth at a height of from four to ten feet above the ground. Their usual call note is a loud, grating, rather nasal *beent*. Sometimes they break out into a series of harsh squeaky sounds. They perch motionless on some bare twig or other exposed position, and dart out after insects on the wing in flycatcher fashion.

Todies nest in holes in banks. Their nest holes are often observed, but I have never dug out one. They are generally dug in the faces of steep banks of the red clay which is characteristic of the humid regions of Porto Rico. The holes are said to go in straight for a short distance, and then turn at right angles to the right or left. From three to four white eggs, very large for the size of the bird, are said to be laid (cf. Gundlach, 1878, p. 219; Wetmore, 1916, p. 64). Apparently the nesting season begins in March and extends to June or July.

The food of the Tody consists mostly of insects, though some vegetable matter is eaten. The stomachs of three birds collected at Mayagüez in December were examined. Animal matter formed 97.66 per cent, and vegetable matter 2.34 per cent. Two large flies (*Volucella obesa*) formed 17 per cent of the animal matter; a cockroach ootheca, 13.3 per cent; weevils, 5 per cent; earwigs, 10 per cent; fleabeetles (*Phyllotreta guatamalensis*), 6 per cent; Membracidae, 5.3 per cent; large insect egg, probably of a moth, 1.6 per cent. The rest of the animal matter consisted of insects too finely comminuted for identification. The vegetable matter consisted of seeds, among which those of the fresa (*Rubus sp.*) were identified. The Tody is a very useful species to the coffee grower, and deserves absolute protection.

62. *STREPTOCERYLE ALCYON* (Linnaeus). Belted Kingfisher. *Pájaro del rey.*

The Belted Kingfisher is a common winter visitant to Porto Rico from September to April, but it is decidedly uncommon at Cartagena Lagoon. It is much more frequenly seen along the seacoast and in the mangrove swamps. All my Cartagena Lagoon records are between September 23 and October 14, 1924. At least two individuals were present during that time. At Anegado Lagoon I observed this species on March 4 and April 1, 1922. My latest spring record for the Island is April 11, 1922, at Quebradillas It is my belief that the scarcity of the Kingfisher at Cartagena Lagoon can be accounted for by the scarcity of suitable perching places over the water, nothing higher that a fence post being available. Those that do frequent the lagoon hover with rapidly beating wings, but without changing their position, at a height of about 25 feet over the water in Sparrow-Hawk fashion before diving. Apparently they feed on Killifish (*Pœilia vivipara*), as when they dive they come up with small fish and this is the only common species of small fish at the lagoon. The Kingfisher is greatly sought by hunters on account of its striking appearance rather than the delicacy of its flesh. The fish taken are not of value as food for man, so it is not directly injurious.

63. *MELANERPES PORTORICENSIS* (Daudin). Porto Rican Woodpecker. *Carpintero.*

The Porto Rican Woodpecker is very rare at Cartagena Lagoon if it occurs there at all. I have never seen any there, but I have seen one on some dead stubs at Anegado Lagoon, and have no doubt that the species at least occasionally visits the larger trees in the Varronia association.

The Woodpecker is common wherever there are many trees, particularly in the coffee *fincas,* where it inhabits the large trees which are grown to shade the coffee. It has a great variety of call notes, the commonest of which is a slightly metallic, but not sharp, series of *works.* It suggest to some the sound of a large muffled sleighbell in the distance. In the spring some call notes suggesting the syllables *wit, wit wit-er-r-r-r-* are heard. Other notes heard at times are a series of *kuks* somewhat like the clucks of a hen, and a sound somewhat resembling the mews of Catbird, but having also a resemblance to the cry of the Sparrow Hawk.

For nesting purposes the Woodpecker excavates a hole in a dead tree. One that I observed in use at Quebradillas was in a dead cocoanut palm, while one at Mayagüez was in dead almendro (*Terminalia catappa*). Both were at heights of about 20 feet above the ground. The hole in the almendro was already occupied in February, but no young birds on the wing were noted until June.

The stomach contents of a male collected at Mayagüez September 25, 1924, were examined. It had eaten entirely animal matter, of which wood-boring Longicorn larvæ formed 90 per cent; a Tenebrionid beetle, 5 per cent; and an adult Longicorn, 5 per cent. Woodpeckers are peculiarly useful birds, obtaining insects which bore in the wood or live under the bark, which few other birds are adapted to obtain. This is the only woodpecker found in Porto Rico, so it should by all means receive all protection. It is possible that in some cases they might do damage by boring in cocoanut palms or other trees, in which case those individual birds should be destroyed.

34. *CHORDEILES VIRGINIANS MINOR* (Cabanis). Cuban Nighthawk
Capacho.

The Cuban Nighthawk is an uncommon summer visitant, and may nest in the vicinity, though I have no direct evidence of this. On three occasions on cloudy afternoons I have observed a single bird flying over the lagoon. These days were May 27, June 7 and 28, 1924, and moreover, these are my only records for the Island. Stahl (1887, p. 451) states that it is a rare summer visitant, found from April to October, and that it nests on the Island. It is certainly rare.

65. *NEPHOECETES NIGER NIGER* (Gmelin). West Indian Black Swift. *Golondrina.*

The Black Swift is a rare resident in Porto Rico,. and Struthers (1923, p. 475) observed it at Cartagena Lagoon on August 29, 1921, and February 4, 1922. It has never been my good fortune to observe it there, though I observed a flock of forty over the then dry Anegado Lagoon on March 29, 1924. That is a greater number than I have seen on the rest of the Island during nearly two years' residence. This species is never observed except in the early morning and just before dusk. It is most commonly observed from May to July. In addition to Anegado Lagoon I have records from Mayagüez (various dates from March 31 to July 28); Filial Amor (May 16); Guaniquilla (June 28). It is usually observed either singly or in flocks of three. Dr. Wetmore (1916, p. 74) reports that two Black Swift stomachs contained only injurious insects. Swifts are among our most useful birds, and as this is the only swift found in Porto Rico it is regrettable that it is not more common.

66. *CHLOROSTILBON MAUGAEI* (Audebert and Vieillot). Porto Rican Emerald. *Zumbador. Zumbadorcito.*

The Porto Rico Emerald, the smallest Hummer found in Porto Rico, is occasionally observed at Cartagena Lagoon, though more abundant in more wooded regions. It is about half an inch shorter than the familiar Ruby-throat of the North. At the lagoon it is most often seen in the Varronia association or in the bamboos, or else flying across the marsh enroute to one or the other. At Mayagüez it is much commoner. Among its favorite flowers are those of the Rangoon Creeper. It is sometimes observed at sugar cane flowers. It is frequently seen gathering something, presumably insects, from the under sides of banana leaves. On January 25, 1924, I observed one hovering at a tree fern trunk for as long as three minutes. Whether it was obtaining some minute insects for food or some of the fluffy, scaly material on the trunk for nest material I cannot say, but I believe insects were more likely the object of its quest as it did not appear to have anything in its bill when it flew away. They are very quarrelsome birds, and bold despite their small size. A pair which apparently had a nest on the Experiment Station Grounds at Mayagüez in May, 1924, often scolded and pursued a Sparrow Hawk which fed in the vicinity, but the hawk never appeared to notice the angry little Hummer.

The stomach of a bird which I obtained at Mayagüez December 20, 1923, contained only a microscopic chalcid fly, and that of one collected June 30, 1924, contained a mass of microscopic fragments of what appeared to be very small Diptera.

67. *ANTHRACOTHORAX VIRIDIS* (Audebert and Vieillot). Green Mango.
Zumbador. Zumbador Verde.

The Green Mango is the Hummer most regularly seen at Cartagena Lagoon, though at most places in the coastal lowlands the Porto Rican Mango is by far the commonest species. A pair of Green Mangos apparently nested in or near the bamboos lining the stream just west of the lagoon, and they were sometimes seen flying over the marsh, though they did not appear to obtain any food there. In the humid part of the Island this is largely a species of the coffee *fincas*. A male which I frequently observed in the hills between Mayagüez and Añasco could almost always be found perched on a certain dead twig of one of the orange trees which occur frequently scattered among the coffee bushes and shade trees of the coffee *fincas*. In the early mornings while the woods were still dripping from the drenching rains of the previous afternoon he could be observed occupying a higher perch in the top of the same tree, sunning himself and preening his feathers. During the day he would occasionally make feeding tours, always returning to the same perch. Rangoon Creepers are perhaps the favorite flowers of this species, as of the other Hummers. It also obtains food from the under sides of banana leaves. When the Rangoon Creepers are in full blossom I have seen as many as four males feeding at once at one small patch, but when too many fed near together there was always fighting, accompanied by sharp squeaks.

68. *ANTHRACOTHORAX AURULENTUS* (Audebert and Vieillot).
Porto Rican Mango. *Zumbador.*

The Porto Rican Mango, although the commonest Hummer in most of the coastal lowlands of Porto Rico, is the rarest at Cartagena Lagoon, where I have only one record, that of three birds seen flying over the lagoon on October 14, 1924. At Anegado and Guánica Lagoons this species is really abundant, and it is very common in the brushy growth back of the beach at Boquerón and at Mayagüez and other places near the coast, though less common in the hills than *A. viridis*. Among its favorite flowers are those of the Rangoon Creeper; the Guango or Rain Tree (*Pithecolobium saman*); the orange-flowered *Leonotis nepetaefolia*, and sugar cane. I have also observed them probing cotton bolls. They are very pugnacious birds, and squeak loudly when quarreling.

On April 1, 1922, I found a freshly completed nest ready for eggs at Anegado Lagoon. It was placed in the fork of a small branch of a thorny tree, at a height of five feet from the ground. It was constructed of fresh green lichens and cat-tail down, and was about twice as large as any Ruby-throat nests I have seen in the United States. The owners were buzzing angrily around while I investigated the nest.

I collected four Porto Rican Mangos (a female at Mayagüez, December 21, 1923; a male at Boquerón, March 8, 1924; and two males at Guánica Lagoon, October 3, 1924). Animal matter formed 97.5 per cent of their food, and vegetable matter 2.5 per cent. The vegetable matter was all rubbish. Of the animal matter, the following were identified: Small brown ants, 6.2 per cent; flower spiders (*Misumena* sp.) 8.9 per cent; Dolichopodid flies (*Psilopus* sp.), 12.5 per cent; Cecidomyid flies, 6.1 per cent; other Diptera, 10 per cent; small Dipterous larvæ, 1.2 per cent; Chalcids, 10 per cent; small bees, 7.5 per cent; small Coleopterous fragments, 16.2 per cent. The insects eaten appear to be injurious with the exception of some of the small Hymenoptera.

69. *TYRANNUS DOMINICENSIS DOMINICENSIS* (Gmelin). Gray Kingbird. *Pitirre.*

The Gray Kingbird is an abundant permanent resident at Cartagena Lagoon. It feeds in all parts of the marsh, but is most abundant in the Varronia association. It nests in the Varronia, Tachuelo and Bamboo associations; in fact, wherever there are any trees. It is a noisy bird, and is heard constantly from morning to night until one becomes almost tired of hearing them. The native name "pitirre" is an imitation of the call note. It is the earliest bird to awaken in the morning with the exception of the Antillean Killdeer, though the Jamaican Mockingbird and the Porto Rican Petchary follow soon afterwards. They are very pugnacious, and are continually pursuing Hawks, Blackbirds, Vultures, Killdeers, Sandpipers and other birds. They are expert at catching insects in the air, and are one of the few birds which can catch dragonflies on the wing. I have even seen one catch one of the large green and black species, the swiftest of all the dragonflies at the lagoon. Although catching a large part of their food on the wing, the Pitirre often descends to the ground to pick up insects. Once a Pitirre was observed catching flies that swarmed around a rotten fish. They often swoop down to the surface of the water either to drink or to pick up aquatic insects or both, making a little ripple as they do so.

FIG. 42.—Nest of Porto Rican Grasshopper Sparrow Open Fields Association

FIG 44.—Female Porto Rican Golden Warbler on Nest in Cat-tails

FIG. 45.—Louisiana Water-thrush Feeding Young, at Ithaca, N. Y. This species occurs as a winter visitor in Porto Rico

This species is found in practically all parts of the Island, from the mountain tops to the sea, but is most abundant along the semiarid south shore, and is very scarce in well-wooded areas.

The nesting season apparently extends from April through June or into July. The nests are placed in trees at a height of from ten to twenty feet from the ground. They are cup-shaped affairs, made of twigs and lined with coarse grasses Three eggs are the usual number. A vari-colored species of cockroach (*Aglaopteryx diaphana* Fabricius) abounds in the Pitirre nests, living among the twigs, also a cricket and a black and yellow ant.

The stomachs of two Gray Kingbirds from Cartagena Lagoon and of one from Mayagüez were examined. The lagoon birds had eaten exclusively animal matter. Included in this were two large wasps (*Odynerus* sp.), 45 per cent; one small wasp, (*Megacanthopus* sp.), 5 per cent; one Sesban weevil (*Tyloderma* sp.), 3 per cent; 1 jumping spider, 5 per cent, and the rest was insect matter too finely comminuted for identification. The Mayagüez bird had eaten a large blue wasp and the fruit of a Cucurbitaceous vine. The Gray Kingbird has a great fondness for Hymenoptera, but as Dr. Wetmore shows (1916, p 76) it also eats many injurious insects, and is an extremely useful bird

The Gray Kingbird is no more abundant at Cartagena Lagoon than it is in the surrounding country Open country is the chosen habitat of this species, and wherever there is open country it abounds.

70 *TOLMARCHUS TAYLORI* (Sclater) Porto Rican Petchary *Clérigo*

The Porto Rican Petchary is a very rare bird in the region of Cartagena Lagoon My only two records are of birds seen in the Bamboo Association April 11 and August 23, 1924 At Mayagüez it is a common species, and I have also observed it at Anegado Lagoon, Guayabal, Peñuelas, near Aibonito, near Santa Isabel and near Utuado. It is most abundant in well-wooded regions, including the coffee *fincas*. In general appearance this bird is quite similar to a Gray Kingbird with a dark brown substituted for the gray of the upper parts, appearing almost black on the head. It is a less aggressive species than the Gray Kingbird, and is seldom observed pursuing other birds. The notes are louder and harsher, but are not uttered as constantly throughout the day, although they are very noisy for awhile at daybreak. They are slightly more noisy in the breeding season than at other times. A bird was observed carrying nesting material at Mayagüez on February 9, 1924, but I have never actually observed the nest of this species. I did not examine any stomachs of the Petchary, but Wetmore (1916, p. 80) found it to be an extremely beneficial species. Its scarcity at the lagoon is accounted for by the lack of woods.

71. *MYIARCHUS ANTILLARUM* (Bryant). Antillean Flycatcher. *Jüi.*

The Antillean Flycatcher is another species which is very rare at Cartagena Lagoon, though rather common in other parts of the Island. My only record at Cartagena is that of a bird heard in the Varronia association April 22, 1924. At Mayagüez it is a rather common species, and it is much commoner at Anegado than at Cartagena Lagoon. I have also observed it at Juana Diaz. Its native name *jüi* (pronounced *whee* in English) is an imitation of its unmistakable note. It is most common in coffee *fincas* or other places where there is dense cover. It is a quiet and somewhat secretive species and is easy to overlook unless heard. It catches insects on the wing. It is said to nest in holes in trees. The stomach of one bird collected at Anegado Lagoon March 29, 1924, contained a brilliant red and green Scarabeid beetle, 60 per cent; miscellaneous insect fragments, 32 per cent; and a few small berries, 6 per cent.

72. *BLACICUS BLANCOI* (Cabanis). Porto Rican Pewee. *Bobito.*

Although I have no actual Cartagena Lagoon record for the Porto Rican Pewee, it would be surprising if it does not occur occasionally in the Varronias, as it is found in similar situations in other parts of the Island. It is principally a bird of the coffee *fincas* and other regions with dense cover. It perches on dead twigs and makes short flight after insects in true Pewee style. Its call note has been well described by Wetmore (1916, p. 83) as "a low tremulous *pree-e-e-e.*" The birds are very easily overlooked unless calling, and the call note is so inconspicuous that one is apt not to notice it until his ears are trained to hear it. The stomach of a bird taken at Mayagüez June 24, 1924, contained 60 per cent of animal matter and 40 per cent of vegetable matter. The animal matter consisted of two Membracids (80 per cent); fleabeetles, 4 per cent; and a small Lepidopterous larvæ, 16 per cent. The vegetable matter consisted of 30 seeds, apparently of some fleshy fruit or berry.

73. *AGELAIUS XANTHOMUS* (Sclater). Yellow-shouldered Blackbird. *Mariquita.*

The Yellow-shouldered Blackbird is a common resident at Cartagena Lagoon. It comes to the marsh to feed, but nests in trees away from the marsh proper. It lives in flocks at all times of the year. The flocks are of small size during the greater part of the year, but after the breeding season in June flocks containing as many as 250 individuals are observed feeding in the canefields. Flocks of *Holoquiscalus n. brachypterus* often contain a few of this species They feed in all the plant associations of the marsh except the open water, and they also feed in places far from the marsh, though not so commonly. None are found in the higher mountains.

When a bird is shot and injured its comrades gather around with sharp cries. The ordinary call note is a rather sharp metallic *chink,* and they also have a typical blackbird *chuck.* The song is a rather wheezy affair and is seldom heard. Near the lighthouse at Cape Rojo many of these birds congregate in the mangroves at dusk to roost.

The nesting season is in May and June. Where Cocoanut and Royal Palms are found the nests are placed in the axils of the large leaves. Near Cartagena Lagoon where palms are scarce these birds nest in colonies in the larger trees of the Varronia association, often in the same trees with the Grackles, at a height of about thirty feet from the ground. The birds are very noisy when their nests are approached, uttering sharp, high-pitched scold notes. Some young were on the wing by May 28, but others were still in the nest the middle of June. A female collected October 14, 1924, was molting badly.

The Yellow-shouldered Blackbird apparently has but few enemies, as it places its nests in quite inaccessible positions, and it is seldom shot at. The Mongoose undoubtedly obtains a few while feeding on the ground.

A flock of these birds lived near a poultry yard at the edge of a small swamp at Mayagüez, and fed on what grain they could pick up, supplemented by a little food obtained in the swamp. These birds also probe the blossoms of Guamá (*Inga laurina*) and Bucare (*Erythrina* sp.) and other trees for insects and apparently for nectar.

Animal matter formed 92.2 per cent of the food in the stomachs of five birds collected at Cartagena Lagoon in April and October, and vegetable matter 7.8 per cent. The vegetable matter consisted of finely ground seeds, among which were those of Malojillo Grass (*Panicum barbinade*) and Foxtail Grass (*Chaetochloa*) were identified. The animal matter eaten was quite varied. Items identified were: Aphids, 11.6 per cent; weevils (*Tyloderma* sp.), 4.6 per cent; Fleabeetles (*Systena basalisq*, 6.0 per cent; Longicorn beetles, 8 per cent; other Coleopterous fragments, 18.4 per cent; Naucoridæ (Pelocoris femoratus), 1.6 per cent; Notonectidæ (*Notonecta undulata*), 1 per cent; aquatic Stratiomyid larvæ, 9 per cent; Syrphid adults, 5 per cent; two leaf-rolling caterpillars (*Dichomeris* sp.), 1 per cent; other Lepidopterous larvæ, 17.6 per cent; fish scales, 1 per cent. The moth *Dichomeris* belongs to the same family (Gelechiidæ) to which the Pink Bollworm belongs. In addition to the food, gravel was found in four out of the five stomachs, but formed only 2.2 per cent of the total contents.

The Yellow-shouldered Blackbird, though closely related to the Red-winged Blackbird, exhibits striking differences in its choice of nesting sites. Although it feeds more commonly in the marshes than elsewhere, it resorts to tall trees, usually at some distance from the marsh, to nest. It is quite an omnivorous feeder, and apparently frequents the marsh more because food is more abundant there than from any special liking for aquatic food or adaptation for life in the marshes. In other words, it has not acquired the "marsh habit" strongly enough to nest there or to restrict its feeding to the marsh, and in this respect it is probably more like the ancestral stock from which both the Yellow-shouldered and the Red-winged Blackbirds have descended.

74. *ICTERUS-PORTORICENSIS* (Bryant). Porto Rican Oriole. *Calandra. Mariquita.*

The Porto Rican Oriole is an uncommon resident at Cartagena Lagoon, where it is found only in the Varronia and bamboo associations. It is a common species at Mayagüez, and at most places in the humid regions of the Island, from the high mountains to the sea, and it is not at all uncommon in the semiarid south coastal region where there is sufficient brushy growth to provide suitable shelter.

This species is easily confused with the Yellow-shouldered Blackbird by the beginner, but it is easily distinguished by having a yellow crissum in addition to the yellow shoulders. The sexes are alike, but immature birds are plain greenish brown. Specimens in interesting pied plumage are sometimes observed. I obtained a male in such a plumage at Cartagena Lagoon on March 21, 1924. While feeding these Orioles often swing with their heads down. They often visit blossoming trees, apparently to obtain nectar and flower-frequenting insects.

The Porto Rican Oriole is perhaps the best singer among the Porto Rican birds, in fact it is almost the only one which can be said to have a musical song, but unfortunately it seldom sings. The lack of bird song is one of the most noticeable features of Porto Rico. The Oriole has two very distinct songs. The commoner one is a clear, highpitched whistle of several notes delivered in a somewhat rambling fashion. The other is a quickly uttered series of four notes strongly accenting the third, thus: *Whip, whip, WHEE-ah.* I am inclined to believe that the second song is the song of the female. Christy (1897, p. 325) records the singing of the young female in transitional plumage of *Icterus dominicensis,* a very closely allied species found in Santo Domingo, and states that its song differs from that of the male, so it would not be unreasonable to suspect that the Porto Rican species does likewise. The season in which this species sings is from February to May On very rare occasions songs are heard at other times of the year. The breeding season is apparently quite extensive. I have observed young able to fly being fed by the parents at Mayagüez on December 8, 1924. They made a great fuss when the young were approached too closely. On December 18, another pair was observed feeding young.

The stomach contents of four Porto Rican Orioles were examined. Two collected at Cartagena Lagoon in March and September contained 99 per cent of animal matter and 1 per cent of vegetable, the latter consisting of a little rubbish. The insect matter identified included a Tortoise Beetle, (*Chelymorpha*), 6 per cent; a Lamellicorn beetle, 6 per cent, a green Chrysomelid, 4 per cent; a weevil, 8 per cent; other Coleopterous fragments, 5 per cent; cockroach fragments, 1 5 per cent; parts of a butterfly, 1.5 per cent; and a small fly, 0.5 per cent, but most of the contents were too finely comminuted for identification. One grain of white sand was found in one of these stomachs. A specimen collected at Guánica Lagoon October 3, 1924, had eaten two Carabid beetles, 40 per cent; 1 weevil, 20 per cent; 1 Bupestrid, 20 per cent; and other beetle fragments formed 20 per cent. A bird collected at Mayagüez December 25, 1923, had eaten 1 sugar-cane root-borer (*Diaprepes spengleri*), 12 per cent, and 12 small fleshy fruits, 88 per cent.

75. *HOLOQUISCALUS NIGER BRACHYPTERUS* (Cassin). Porto Rican Grackle. *Mozambique. Chango. Pichón prieto.*

The Porto Rican Crackle is one of the most abundant residents at Cartagena Lagoon. It feeds in all the plant associations except the open-water, and nests in the cat-tail and Varronia associations.

This is the commonest bird of the coastal lowlands of Porto Rico. It is found less commonly in the foothills, and I have never seen it in the mountainous interior of the Island. It is particularly abundant around cultivated fields, where it is generally regarded as the most beneficial species on the Island on account of the injurious insects which it destroys. When the canefields are plowed flocks of these birds may almost always be seen following the plow to pick up white grubs, mole crickets and other insects that are turned up by the plow.

The tail of this species has a peculiar form, the lateral tail feathers being elevated above the level of the intermediate ones, forming a letter V. This is particularly noticeable when the birds are in flight, making them appear almost deformed. Their notes include a grackle-like *chuck* and a great variety of squeaky notes.

These grackles are almost always found in flocks. In fact, they are of so social a nature that several pairs usually place their nests near together, many nests being found in the same tree. The ordinary nesting place is in large trees, usually palms when these are available. Near Cartagena Lagoon where there are but few palms they nest in Jobo trees (*Spondias nombin* L), West Indian Elms (*Guazuma ulmifolia* Lam.), Ceibas, (*Ceiba pentandra* L.), and other trees, often placing their nests among the parasitic plants which grow commonly on the branches. One ceiba tree near the lagoon contained a colony of 25 nests. Having become accustomed to seeing mozambiques nesting in tall trees, I was much surprised when I discovered them nesting quite commonly in the cat-tails at the lagoon, at heights of about four feet above the water. The nests are built of grass and roots and mud is often used in their construction. The largest number of eggs I have found in a set is five, and four appears to be the common number. The eggs are very variable in color and markings, but most of them have a putty-colored background marked with brownish-red scrawls and blotches. I have found nests from April to August, and I believe that some may nest even later. All of the many cat-tail nests found were broken up before the young hatched, mostly by boys who wantonly destroyed the eggs. They could not resist the temptation of seeing an egg of any kind and taking it, even though too small to eat. Small eggs and eggs with large embryos were simply broken and destroyed. It is a very pernicious habit, and everything possible should be done to combat it. Possibly more nature work in the schools would teach the children to have more respect for wild animals.

I noted young birds being fed by an adult at Mayagüez as late as January 8, 1924.

For several years there has been a Mozambique roost in some cocoanut palms on the shore at Peña Cortada, a short distance north of Mayagüez. Towards dusk many long straggling flocks of these birds can be seen flying north just back of but parallel to the beach, sometimes just above the tops of the cocoanut palms which line the beach, sometimes just below them. At least 3,000 birds were using this roost in October, 1924, and probably many more than this. Country people who live near the roost say it is used at all times of the year.

Although the Mozambiques are useful in destroying insects they also have a less desirable habit of feeding on the lizards (*Anolis*) which so abound in Porto Rico. They have a very clever method of catching these. In describing this habit I cannot do better than to quote from notes made by my father, Prof. Ralph E. Danforth, of the Agricultural College at Mayagüez. "The Mozambiques pursue the lizards on the trees, surrounding the trunk so that the lizards are caught unless they get into the grass in time. Sometimes they try to hunt singly, but seem more successful when several work together. Sometimes hens profit by the work of the Mozambiques, and follow them from tree to tree to seize the lizard the moment the Mozambique drives it down. But even so, many of the lizards escape into hiding. When a Mozambique catches a lizard it flies to a branch and holds the lizard in its feet against the branch while it squeezes the life out of it with its bill, pinching it rapidly from end to end by a series of quick pinches. Then it takes it in its bill and passes it back and forth through the bill, from end to end, by a series of rapid motions like those made by a duck's bill in the water, and finally swallows it whole when it is sufficiently soft and limp." On the grounds of the Federal Experiment Station at Mayagüez there is a grove of closely planted Dwarf Bucare trees (*Erythrina corallodendron* L.), used as supports for vanilla vines. The Mozambiques spend a great deal of time in this grove hunting lizards, but they also hunt them on larger shade trees, such as the Mango.

At the lagoon the flocks of Porto Rican Grakles often contain a few Yellow-shouldered Blackbirds, and the two species place their nest in the same colonies in the large trees. In September and October many tailless molting birds are observed.

In a newly plowed canefield near the lagoon I observed a Porto Rican Grackle swallow a five inch centipede entire. These are very poisonous to humans. I have also seen one eating the seeds of the Cundeamor (*Momordica charantia*), though but little vegetable matter is eaten. Six stomchs of birds taken at Cartagena Lagoon in March, April and October were examined. These contained 94.5 per cent of animal matter and 5.5 per cent vegetable matter. The animal matter identified included the following: Cockroaches, 13.3 per cent; grasshoppers, 1.7 per cent; katydid (*Neoconocephalus*), 5 per cent, dragonfly, 1.3 per cent; adult Neuroptera (*Sialidæ*), 1.3 per cent; butterfly caterpillar, 1 per cent; moth pupa, 0.3 per cent; weevils, 8.3 per cent; Dytiscid larvæ, 5 per cent; Bupestrid (*Chrysobothrys* sp.), 1.7 per cent; tortoise beetles, 1.3 per cent; fleabeetles, 2 per cent; other Coleoptera, 26.3 per cent; Bloodworms, 0.3 per cent, spiders (*Aranea* sp.), 1.3 per cent; slugs, 4.3 per cent; snails, 3.9 per cent; black down feathers (probably their own), 0.7 per cent; pieces of eggshell, 1.3 per cent; fish scales (*Poecilia vivipara*), 1.3 per cent (probably of dead fish picked up along the shore). The vegetable matter, in addition to rubbish, consisted of grass, 33 per cent; and seeds of *Panicum* sp., 33 per cent. One stomach contained a little coarse gravel, amounting to 1 per cent of the contents of that stomach. The stomach of a bird collected at Mayagüez in December contained no food but the pulp of some fruit, but it also contained some very large pieces of white gravel forming 20 per cent of the contents.

Thus it will be seen that the Porto Rican Grackle is quite an omnivorous bird, adapted to obtain food in swamps or on dry land, in humid or in semi-arid regions. It nests either in high trees or in the cat-tails of the marsh. It is a very adaptable bird, thriving under many varied conditions, though showing no special adaptations to any one of them. It is scarcely more abundant at the lagoon than elsewhere. Although apparently varying its diet occasionally with bird's eggs, and consuming many lizards at times, most of its food consists of injurious insects, making it a highly benefical species worthy of full protection.

76. *AMMODRAMUS SAVANNARUM BORINQUENSIS* (Peters). Porto Rican Grasshopper Sparrow. *Gorrión*.

This Grasshopper Sparrow is an uncommon resident in the fields just north of the marsh proper. The only other place on the Island at which I have found this species is in the dry fields near Guánica Lagoon. In 1924 there were apparently three pairs breeding in the open-field association at Cartagena Lagoon, although there was only one pair in 1922. The males usually sing on the ground, only on rare occasions mounting on weedstalks of slight elevation for this purpose. The song does not differ noticeably from that of the North American form. The birds appear to nest more or less throughout the year. Young on the wing were noted May 13; the young in a nest under observation hatched May 27, while specimens which appeared to be breeding birds were collected at Cartagena Lagoon August 13, 1924, and at Guánica Lagoon October 3, 1924.

The one nest which I found was built entirely of fine grasses, and was arched over like the nest of a Meadowlark. It was on the ground, largely concealed by a tuft of dry grass. It contained three eggs, similar to those of *A S. australis*, on May 23, 1924. When the nest was approached the incubating bird scooted away from it like a rat running along the ground. The young hatched on May 27. On May 30 the young had small wing quills and some puffs of down and their eyes were open. On June 3 the nest had been crushed and robbed, apparently by that villain the Mongoose. Such is doubtless the fate of many a young Grasshopper Sparrow. The wonder it that any ground nesting birds are left in a region where the Mongoose is so abundant.

The stomach of the bird collected at Cartagena Lagoon in August contained about 50 small beetles amounting to 95 per cent of the contents. Ten grass seeds (*Chloris paraguaiensis*) formed the rest. Animal matter formed 98 per cent of the food of the Guánica bird, and consisted of 2 slugs (94 per cent); 1 weevil (2 per cent); 1 small Locustid Grasshopper (1 per cent) and finely comminuted insects (3 per cent). The vegetable matter (2 per cent) consisted of 3 seeds of *Panicum* sp. In addition, one large grain of sand was found in this stomach.

The Porto Rican Grasshopper Sparrow does not have a chance to become very common, as it prefers old fields, and the land is so intensively cultivated in Porto Rico that but few such fields are left for it.

77. *TIARIS BICOLOR OMISSA* (Jardine). Carib Grassquit. *Gorrión.*

The Crib Grassquit is a common resident at Cartagena Lagoon, where it inhabits the Varronia, Bamboo and open-fields associations, and nests in the first two mentioned. It is primarily a bird of the open country, but it needs a certain amount of cover for nesting purposes. A few are even found in dense woods. In most parts of the Island it is a very abundant species, being perhaps the most abundant species on the Island with the exception of *Coereba portoricensis* and *Holoquiscalus niger brachypterus*. It is found very abundantly in the canefields whenever there is cover nearby. The birds are not shy. The song is a harsh vibrating *zee-e-e-e*. They sing from exposed perches. The males sometimes spread their wings while singing. The call note is a low *tsip*. Small flocks of young may be noted at all times of the year, and the adults breed throughout the year. Apparently several broods a year are raised. The nests are globular affairs, made of grasses, sometimes with the addition of a little paper, and lined with finer grasses. They are quite similar to the nests of *Coereba portoricensis*, but the opening is always at the side instead of at the bottom as in those of the latter species.

The nests are placed in maya plants or shrub or trees at heights varying from a few inches to twelve feet from the ground. Usually they are well concealed, but occasional nests are found in very exposed positions. One such nest was placed at a height of one and a half feet in an orange seedling not over six inches from a much-used cement walk in Mayagüez. The birds paid for their folly by having their nest broken up when only two eggs had been laid (June 26, 1924). At Cartagena Lagoon the nests are placed in the mayas which grow in the Varronia association, or in the trees and shrubs which grow in that and the Bamboo association. The two highest nests I found there were one six and a half feet in a *Ricinella ricinella* tree, with three eggs on July 2, 1924; and one five feet in a bamboo with three eggs on October 11, 1924. The usual number of eggs laid is three. They are white, heavily spotted with red, especially at the larger end.

Only one stomach of this species was examined, that of a breeding male taken at Cartagena Lagoon. Its legs were badly infected with mites. The food consisted entirely of small seeds. In addition a feather, probably one of the bird's own feathers, and a little sand (5 per cent of contents) were found. In the field they have been observed to eat green leaves, especially those of *Hibiscus*. Field observations indicate that grass seeds are the main food of this little finch. Large flocks appear when the Guinea Grass and Malojillo Grass seeds are ripe.

78. *TIARIS OLIVACEA BRYANTI* (Ridgway). Bryant's Grassquit.
Gorrión.

Bryant's Grassquit is a common species, though not nearly as common and less generally distributed than *Tiaris b. omissa.* At Cartagena Lagoon it is found rather uncommonly in the Varronia, Tachuelo and open-fields associations. It is more strictly a bird of the open country than the Carib Grassquit. It is commoner in the eastern than in the western half of the Island. It is found singly or in small flocks of three or four individuals. It is a little shyer than the other Grassquit, and can seldom be approached as closely. The males sing their weak trilling song, somewhat suggestive of a grasshopper, from some conspicuous perch. The call note is a faint *tseep.* I have never found their nests at Cartagena Lagoon, but believe that a few nest in the Varronia association. A male collected while singing there on September 17, 1924, had extremely large testes indicating breeding.

These little Grassquits appear to eat seeds almost exclusively. The one stomach examined from Cartagena Lagoon contained only seeds of some grass, possibly *Paspalum.* In the field they are observed to eat the seeds of Guinea Grass and other grasses.

79. *LOXIGILLA PORTORICENSIS* (Daudin). Porto Rican Grosbeak
Come gandul.

The Porto Rican Grosbeak probably occurs occasionally in the Varronia association, though I have no actual records for the vicinity of the lagoon except upon Tinaja Hill just south of the lagoon. It is very common or even abundant in most places in the humid part of the Island where there are many trees, but it is so secretive in its habits that one seldom realizes how abundant it really is except when singing freely. Unlike most birds, it keeps well hidden while singing. It has two distinct whistled songs. That most frequently heard is a *whip, whip, whip, whip, whee-e,* becoming faint at the last syllable, which sometimes takes the form of a faint trill. This song has somewhat of a resemblance to the song of the Cardinal.

The other song is a very emphatic *coóchi, coóchi, coóchi, coóchi,* and is pitched a little higher than the other song. Birds singing this song are sometimes answered by nearby birds with the other song. The scold note is a low metallic *wheent*.

I have never observed an occupied nest of this species, but on April 10, 1924, near Mayagüez, I found a deserted nest which could scarcely belong to any other species. It was a bulky affair built mostly of leaves, lined with grass, and placed about ten feet above the ground in a tangle of vines in a small patch of second-growth woods.

80. *SPINDALIS PORTORICENSIS* (Bryant). Porto Rican Spindalis. *Reina Mora. Llorosa.*

The Spindalis is a rare bird at Cartagena Lagoon, where I have found it only in the Varronia association. It is a common species in the hills and mountains of Porto Rico, but is rather inconspicuous and lives in secludes places so that it is rather infrequently observed closely, although not shy like the Grosbeak. Once I saw a male in a mangrove swamp near Boquerón. This species is usually seen either in pairs or in small family flocks. The call note is a weak but sharp *tsheep*. The Spindalis has a song, but it is so seldom uttered that Dr. Wetmore (1916, p. 122) supposed it had no song. I have heard it but once in two years. That was very soon after arriving on the Island, so I neglected to make notes on the song, thinking that I would surely hear it often and be better able to record it after becoming better acquainted with it, but the chance never came, so I cannot record it accurately. My impression is that it was a sprightly song of rather weak notes.

In the field I have observed a Spindalis picking aphids from the under side of the leaf of a Calabash tree (*Crescentia cujeta*). When fresas (*Rubus* sp.) were ripe many of these birds came to feed upon them. They also eat many wild fruits and seeds. They may occasionally do enough damage to fruit to warrant their destruction, but apparently they seldom do much damage to cultivated fruit.

81. *SPERMESTES CUCULLATUS CUCULLATUS* (Swainson). Hooded Weaver Finch. *Diablito. Gorrión.*

The Hooded Weaver Finch is a West African species which was introduced in Porto Rico many years ago. It is now very generally distributed over the lowlands of Porto Rico, though much less common in the semiarid southern coastal region. It is quite uncommon at Cartagena Lagoon, and all my records are for the Bamboo association. At Mayagüez it is a very common species. Large flocks congregate where Guinea Grass (*Panicum maximum*) and Malojillo (*Panicum barbinade*) and other grasses are going to seed, often in association with Carib and Bryant's Grassquits and Scarlet-cheeked Waxbills. It apparently has no song, but a metallic call note with a burring quality is often uttered. While feeding these birds keep up an incessant chatter, though occasionally the whole flock will become quiet as though at a given signal.' During the greater part of the year they are never seen except in flocks, which may be of considerable size, but in May and again in October many pairs are seen. On May 18, 1924, I observed the beginning of the construction of a nest in the top of a Royal Palm at Mayagüez. The female was bringing the grass stems and putting them in place while the male looked on. The next time I observed this nest (exactly a month later) the young were making so much noise in the nest that I should judge they were about ready to leave. On July 8 adults were noted feeding young not far away. Apparently a second brood is raised in the fall, for paired birds are again seen. On October 12, 1924, I observed one carrying grass into a Royal Palm, but on October 19, shortly before I left for the States, the nest was not yet half finished No birds were collected, but field observations indicate that grass seeds are the principal food.

82 *ESTRILDA MELPODA MELPODA* (Vieillot). Scarlet-cheeked Waxbill.
Veterano. Gorrión

The Scarlet-cheeked Waxbill is another weaver finch which was introduced from West Africa many years ago. It has never become as widely distributed as the Hooded Weaver Finch, being confined to the region from Yauco to Añasco, but it is very abundant in the part of this region from Yauco to Cabo Rojo, which includes Cartagena Lagoon. At the lagoon it is most frequently seen in the Bamboo, Varronia and open-fields associations, though it is not infrequently found feeding in the marsh proper, especially in the cattail and sedge associations. They are very frequently flushed in the canefields. They are quick and nervous in their actions. When alarmed they have a habit of bunching together and calling continually, though keeping well concealed in the foliage. When flushed they fly but a short ways before dropping into cover, calling loudly while in flight. Their call is a rather metallic chatter, instantly distinguishable from that of any other species on the Island. The males have a rather attractive song, but it is seldom heard. It is a rollicking twitter, which might be set down as follows: *swee-sweet-sweét-er-er,* repeated several times in rapid succession.

Nothing has been recorded of the breeding of this species in Porto Rico, and I can find but scant reference to its breeding habits in its native home in Africa. Alexander (1902, p. 300) records finding nests attached to Elephant Grass in the Gold Coast Colony. Bates (1909, p. 52) writing on the birds of Cameroons says he has not certainly found the nest, but in speaking of E. atricapilla he says he believes that species and some others in the same subfamily are communistic, several females laying in the same nest. I had previously come to suspect that such was the case with *E. melpoda* in Porto Rico. The birds remain in flocks throughout the year, and apparently nest in the Varronia association. Once I thought I had a nest spotted there, but time prevented a thorough search to locate it exactly. When the spot was approached a flock of about eight birds, about five of them females, showed much concern. That, together with the fact that the bird are never seen except in flocks, started me thinking. Soon afterwards Mr. Antonio Ramírez, a student in the Agricultural College at Mayagüez, and a very accurate observer, told me that he has observed the nesting of this species many times near his home in Cabo Rojo. He says that they build nests in the bases of clumps of Yerba de Guinea (*Panicum Maximum*) and Yerba de Burro (*Elephantropus spicatus*), the nests appearing like a wad of grass, and that all the females in a flock lay in the same nest. He says that he has found as many as twenty eggs in one nest, and that they are plain white and quite round. I am now quite firmly convinced of the communistic habits of this species.

These little Waxbills are often observed feeding on the seeds of Guinea Grass and other grasses, sometimes in company with *Spermestes cucullata,* but when flushed each species flies off in a flock by itself. But this species apparently does not confine its diet to grass seeds as *S. cucullata* does, for it is more often seen feeding on other weed seeds. However, the seeds of Malojillo (*Panicum barbinode*) formed 98.3 per cent of the food in the stomachs of three birds taken at Cartagena Lagoon in March, September and October, and the rest were some small red unidentified seeds. In addition to the seeds the stomachs contained sand to the extent of 25 per cent of the total contents. Thus it is seen that it is a species of little economic importance, though flocks feeding in cultivated fields doubtless devour many noxious weed seeds.

83. *PROGNE DOMINICENSIS* (Gmelin). Caribbean Martin. *Golondrina de Iglesias.*

The Caribbean Martin is one of the two species which are definitely known to breed in Porto Rico but winter farther to the South. It is a regular and tolerably common summer resident in the vicinity of Cartagena Lagoon, the first spring records being January 6, 1922 (an exceptionally early date) and February 19, 1924. My latest fall record is September 3, 1924, at the lagoon (September 9 at Mayagüez). The Martins feed to a large extent over all parts of the marsh, but especially over the open water, and nest in some houses at some distance from the lagoon. During heavy showers I have observed these birds perched upon a leafless tree near the edge of the lagoon. At Mayagüez a small colony nests in the ruins of the old courthouse, abandoned after the earthquake of 1918. A few nest in the ventilator holes over the door of a small store on Santiago Veve Street, and a few apparently nest in the belfry of the Catholic Padres' House. Near Quebradillas I found a pair occupying a hole in a partially decayed cocoanut palm in April 1922. There is no apparent reason why this species should not become more abundant if it were supplied with nest boxes and martin houses similar to those used for *P. subis* in the States.

84. *PETROCHELIDON FULVA POECILOMA* (Gosse). Jamaican Cliff Swallow. *Golondrina de cuevas.*

The Jamaican Cliff Swallow is a common resident in the vicinity of Cartagena Lagoon, much scarcer in winter than at other times of the year. It feeds extensively over all the marsh associations. It is particularly fond of skimming low over the Persicarias, apparently feeding upon some of the thousand of moths and other insects which fly up when disturbed by a cow or other animal passing through them. In September tremendous flocks, consisting largely of young birds, appear. They alight on the telephone wires near the railroads, and small detachments at a time take feeding trips over the marsh. None of these swallows nest very near the lagoon, as there are no suitable nesting sites for them. They usually nest on overhung cliffs or in caves. On April 15, 1922, I had the opportunity of observing a nesting colony of about 500 pairs on the face of an inaccessible limestone cliff near Quebradillas. It was impossible to examine the nests closely, but by the actions of the birds I judged that some at least already had young. In August and September large flocks, often containing from 1,000 to 2,000 birds, mainly immature, may be observed on the wires in many localities in the western end of the Island. They feed over cane-fields much of the time.

These birds have a twittering song in addition to their ordinary soft call notes.

The stomachs of three birds collected at Cartagena Lagoon August 13, 1924, were examined. Animal matter formed 100 per cent of the contents. Engraver beetles (*Xyleborus* sp.), formed 2.6 per cent; fleabeetles (*Phyllotreta guatemalensis*), 1.6 per cent; other Coleopterous fragments, 44.2 per cent; wasps (*Polistes crinitus*) 13.3 per cent; ants (small, red-legged species), 3.3 per cent; mosquitoes (*Culex* sp.), 1.6 per cent. The rest of the insects were insects comminuted beyond identification.

85. *HIRUNDO RUSTICA ERYTHROGASTER* (Boddaert) Barn Swallow. *Golondrina.*

The Barn Swallow is a spring and fall migrant at Cartagena Lagoon, commoner in the fall than in the spring. Migration dates obtained are: May 4 to 14, 1922; March 1 to May 23, 1924; and August 26 to September 30, 1924. Cartagena and Anegado Lagoons are the only places in Porto Rico at which I have observed this swallow. On August 26, 1924, about 100 of them suddenly appeared. Their numbers kept steadily diminishing until on September 30 but three were seen, and after that none. They spend most of their time skimming over all the marsh associations, especially the open water. Occasionally they alight on the wire fence which crosses the lagoon. More than half of those seen in the fall are in immature plumage. Three were collected on August 26, 1924. Their stomachs contained exclusively animal matter. Engraver beetles (*Xyleborus* sp.) were found in all three stomachs and constituted 60 per cent of the contents. Other items identified were damselflies (5.3 per cent), deerfly (Chrysops vittatus), 0.66 per cent; Syrphid fly, 1 per cent; Fulgoridae, 1 per cent; Pentatomid, 1.6 per cent. The indications are that this is a very useful species, as would be expected of a member of this highly insectivorous family. While passing through Porto Rico it appears to be restricted to the marshes.

86. *RIPARIA RIPARIA RIPARIA* (Linnaeus). Bank Swallow. *Golondrina.*

The Bank Swallow is a tolerably common spring migrant at Cartagena Lagoon, and I have also seen it at Anegado Lagoon. Migration dates obtained are March 4 (Anegado Lagoon) to April 8, 1923 (Cartagena Lagoon); and February 19 to April 30, 1924, at Cartagena Lagoon. It feeds exclusively over the marsh, and almost exclusively over the open water, either alone or associated with other swallows. Occasionally these birds light on the wire fence which crosses the lagoon. They occasionally utter a rather harsh, gurgling rattling sound, like pebbles rolling together. No stomachs were examined, but the food probably does not differ materially from that of the other swallows.

87. *VIREOSYLVA CALIDRIS CALIDRIS* (Linnaeus). Jamaican Vireo. *Julián chiví.*

The Jamaican Vireo is one of the two species known to breed in Porto Rico and winter further South. It is a tolerably common summer resident at Cartagena Lagoon, being found in the Varronia and Bamboo associations. It arrives later at Cartagena Lagoon than in the more humid regions. In 1924 I noted the first birds at the lagoon on March 17, while they had been common at Mayagüez since February 14. They are such constant singers that it is not easy to overlook them. My latest fall record is August 23, 1924, at the lagoon, and September 8 at Mayagüez. In appearance they are very similar to the Red-eyed Vireo. The song is also quite similar but more hesitating, louder and more emphatic. It seems as though the birds say *John to whit; sweet John to whit; John to whit; sweet John; John to whit.* The birds repeat this with such unvarying monotony from morning to night that where they are common one becomes tired of hearing about "John to whit" all day long, and after the day is over finds himself still doing things to the tune of "John to whit", uttered silently to himself. To one continental American living at Mayagüez this Vireo seems to say "Think you're pretty?" It is almost the only species that sings through the noonday heat of the tropical day. In addition to its song, it has a nasal *whee*, a complaining call note.

The only nest I have observed was found in the Bamboo association at Cartagena Lagoon. It was pensile, compactly constructed of Bamboo leaves and lined with fine grasses. It was placed in a horizontal crotch of a small *Andiva ineuris* tree at a height of seven feet above the then dry bed of the quebrada. When found on July 2, 1924, it contained three eggs. They were white with a few red spots and blotches at the larger end, and measured 21 × 15 millimeters (.81 × 55 inches). The incubating bird did not leave the nest until almost touched, and then stayed near uttering occasional complaining notes. Circumstances prevented me from continuing observations of this nest.

Two birds were collected at the lagoon in April, 1924. The feet of one were very much deformed by a severe attack of mites. The stomachs of these birds contained 12.5 per cent of animal matter and 87.5 per cent of vegetable matter. Fifty-one per cent of the animal matter consisted of beetle fragments, and a smooth Lepidopterous caterpillar formed the other 49 per cent. The vegetable matter consisted of fruits and seeds probably of *Varronia angustifolia.*

88. *VIREO LATIMERI* (Baird). Latimer's Vireo. *Bien te veo.*

Latimer's Vireo is a resident species peculiar to Porto Rico. It is an extremely rare bird in the vicinity of Cartagena Lagoon, my only records being from Tinaja Hill, though I have but little doubt that it is occasionally found in the Varronias. It is quite common in the brushy growth at Anegado Lagoon, and also in the brushy growth on the limestone hills at Ensenada and near Cape Rojo Lighthouse, and I have also observed it near the road between Arecibo and Utuado. It has a sharply accented Vireo-like song which gives it its local name of Bien-te-veo (not *Julian chiví,* as given in other published accounts, in which the local names of this species and of *V. c. calidris* are twisted), but this song is heard less frequently than another song which is quite unlike that of any other Vireo I have heard. It is a rather feeble warbler-like trill, one might almost say insect-like. A third song which is also very suggestive of a warbler is sometimes heard. It is a *wert, wert, weét, wit* uttered in tones not very different from those of Adelaide's Warbler, but more vigorous and louder. A bird which I collected singing this song proved to be a female.

A nest which could hardly have belonged to any other species was found April 25, 1924, on a limestone hill at Ensenada. It was a typical pensile Vireo nest, but it was made of dead leaves mixed with plant fibers and lined with fine plant fibers. It did not yet contain any eggs. It was placed in vines climbing on a brushy tree at a height of five feet from the ground.

The contents of two stomachs were examined. A female collected at Anegado Lagoon March 29, 1924, had eaten 60 per cent of animal matter (a cockroach ootheca and a logicorn beetle) and 40 per cent of vegetable matter (a wild berry with a large flat seed). A male collected at Ensenada April 25, 1924, had eaten 78 per cent of animal matter (a weevil, some other beetles and a little comminuted insect matter) and 22 per cent of vegetable matter (seeds of a pulpy fruit).

This is a species of regions of brushy growth in the semiarid south coastal region, and is found locally to some extent in other places.

89. *COEREBA PORTORICENSIS* (Bryant). Porto Rican Honey Creeper or Bananaquit. *Reinita.*

The Porto Rican Honey Creeper is the most abundant and universally distributed bird in Porto Rico, being found everywhere that trees or brush grow, from the mangroves of the sea to the tops of the highest mountains. However, it is about as scarce at Cartagena Lagoon as at any place I have been; in fact it can hardly be said to be common at all there, though I have quite often seen it in the Varronia and Bamboo associations, and it undoubtedly breeds there in small numbers. It flits among the trees in a very quick and active fashion. It is very tame and often enters houses in search of sweets and other food. It is the latest bird to awaken and become active in the morning. The song is a rather harsh insect-like trill suggesting the syllables *zee-e-e-e-swees-stee,* the first part being pitched higher.

These birds nest during every month of the year. At Mayagüez I found more nests of this species than of all other species put together. They are globular structures placed at the tips of the twigs of trees from 6 to 35 feet above the ground, and are built of leaves and grasses, lined with fine grasses. They may always be distinguished from nests of the Carib Grassquit by the fact that materials other than grasses are used in their construction, and the opening is always at the bottom. Their high position in the tree usually serves to distinguish them also Both sexes assist in nest building. From two to three eggs are laid. Empty nests are used as sleeping quarters. Apparently this species has the same habit of building dummy nests as the Marsh Wren, and the nests of these two birds are also quite similar in appearance. About one out of twenty Honey Creeper nests found are occupied. On several occasions I have watched Honey Creepers build nests and then start tearing them to pieces when hardly completed, using the materials for new nests. Several broods a year are raised, and the young begin breeding while still in the juvenile plumage (less than a year old).

Field observations show that the Honey Creeper is very fond of nectar. It frequents blossoming trees of almost any kind, and is particularly fond of the blossoms of the Rangoon Creeper and of the Bucares (*Erythrina* spp.). I have several times watched these birds sucking the juice of unripe oranges, but in at least one case the hole through the skin was originally made by a Porto Rican Grackle (*Holoquiscalus niger brachypterus*). Honey Creepers are very fond of sweets, and will enter houses to obtain sugar or honey. One pair visited a small store in Mayagüez many times a day to feed on the partly refined yellow sugar which was exposed for sale in an open bin. The stomach is very small, appearing nothing more than a slight swelling at the junction of the esophagus and intestine. It would thus appear that nectar might form a large proportion of the food, as it probably does, but many insects are also eaten. One of three birds collected at Mayagüez in December, 1923, had eaten eight Curculio larvæ, which formed 100 per cent of its stomach contents. The second stomach contained nothing but a fragment of white egg shell, while the third contained 1 Bluebottle fly, 45 per cent; 4 beetles (*Platypus* sp.), 45 per cent; and a little miscellaneous insect matter, 10 per cent.

Boys who wantonly destroy any eggs they can get hold of are perhaps the worst enemy of this species.

90. *MNIOTILTA VARIA* (Linnaeus). Black and White Warbler. *Reinita.*

The Black and White Warbler is a winter visitant, common in the wooded regions of Porto Rico, but rather scarce at Cartagena Lagoon, where it is found only in the Bamboo association. I have found it there only in December. At Mayagüez it is a rather common species. My first fall record is October 12, 1924, and my latest spring records April 29, 1922, and April 21, 1924. It is frequently found in the coffee *fincas*. It often sings for awhile after its arrival in the fall. On October 13, 1924, a bird was singing all day in a small patch of coffee, and I have heard one sing as late as December 19, 1923. One observed in February was continually making sharp *with* scold notes as it gleaned among the twigs of a large tree.

91. *COMPSOTHLYPIS AMERICANA USNEAE* (Brewster) Northern Parula Warbler. *Reinita.*

The Northern Parula Warbler is the most abundant of the migrant warblers in Porto Rico. It is common at Cartagena Lagoon, occurring in the Varronia, Tachuelo and Bamboo associations exclusively. At Mayagüez it is an abundant species. At Cartagena Lagoon my latest spring record is May 2, 1924; corresponding records for Mayagüez are April 15, 1922, and April 22, 1924, and the earliest arrival date I have is September 29, 1924. After March 22, 1924, it was singing regularly until its departure for the north. Birds collected in the spring were extremely fat, and their sexual organs had become quite enlarged. It is common in the Varronias. Frequently around twenty could be counted in a short time there.

Three birds collected at Cartagena Lagoon in April and May had eaten 93.3 per cent of animal matter and 6.7 per cent of vegetable matter. The following items were included in the animal matter: Dragonfly naiad, 2.6 per cent; Fleabeetle (*Systena basalis*), 1.7 per cent; other fleabeetles, 2 per cent; Sesbas weevils (*Tyloderma* sp.), 1.7 per cent; spiders, 1.6 per cent. The vegetable matter consisted of berries of *Varronia angustifolia* and an unidentified seed. Two birds collected at Mayagüez in December had eaten exclusively animal matter. Large moth eggs were eaten by both birds, and formed 25 per cent of the contents. Fleabetles (*Epitrix parvula*) constituted 5 per cent, and other Coleoptera 80 per cent.

92 *DENDROICA TIGRINA* (Gmelin). Cape May Warbler. *Reinita.*

The Cape May Warbler is a very rare winter visitant in Porto Rico and at Cartagena Lagoon, where I saw one in the Bamboo association April 8, 1922. My only other Porto Rican records for this species are one at Mayagüez on February 19, 1922 and one on March 17, 1922.

93 *DENDROICA PETECHIA BARTHOLOMICA* (Sundevall). Porto Rican Golden Warbler. *Canario. Canario de los manglares Reinita.*

The Porto Rican Golden Warbler is a rather common permanent resident at Cartagena Lagoon, where it inhabits all the plant associations except the grass, open fields and open water habitats, but particularly the cat-tails and Varronias. It also nests in all these associations at least occasionally. In other parts of the Island I have found it chiefly in the mangrove swamps, of which it is a characteristic bird. On January 4, 1924, I observed one beside a small stream at Patillas, and it is said by the country people to appear at other inland points points of low elevation, and in such cases to nest in the Guánica (*Guazuma ulmifolia*).

The males sing from February to September to some extent, and almost constantly during the spring months. In 1922 I heard the first song on February 25, and in 1924 on February 6. The song is quite similar to that of *D. aestiva*. The call note is a sharp *chip*. A faint *tsheep* is also heard at times.

The nesting season at Cartagena Lagoon is from April to July or possibly August. The nests are compact cup-shaped affairs, rather similar in appearance to those of *D. æstiva*. The materials used in their construction vary considerably. Usually they are built of grasses with the addition of cat-tail down, and sometimes of roots and other plant fibers. In other nests shredded cat-tail leaves are used instead of grass. Every nest found in the marsh proper had many silky spider-egg coverings worked into the outside of the nest. The nests are lined with cat-tail down, and in two cases after the eggs were laid a few Coot feathers were added. The dimensions of a typical nest are: outside diameter, 2.60 inches; inside diameter, 1.65 inches; inside depth, 1.4 inches; outside depth, 2.55 inches. Nests were found placed in the Cat-tails, Pluckeas, Persicarias and Bamboos at heights varying from 4 inches to 6 feet above the ground, and I am told that in large trees they often nest at considerably greater heights. The number of eggs was invariably three in all the nests found. They are greenish-white, thickly speckled with rufous.

A nest in the 18-foot high cat-tails at the west end of the lagoon was observed with particular care. It was placed at a height of 4 feet above the water, which was 1 foot deep at that point, and a person walking there would sink an additional foot into the mud. The nest was placed where two bent cat-tail leaves gave it support beneath in addition to the support of the upright stems at the sides. It was made of fine fibers shredded from cat-tail leaves mixed with cat-tail down and the customary silky spider egg coverings. When I first discovered the nest on May 16, 1924, it was still in the process of construction, though nearly completed. The female was doing all the work while the male sang about 100 feet away. She was very tame and proceeded with her work while I stood but six feet away. After bringing a billful of material she would place it in the nest and then jump in and turn around to keep the shape right. She was very silent while at her work. When I went right to the nest to examine it closely she hopped around nervously within from two to four feet of me, but made no sound nor other attempt to drive me away. On May 20 the nest was completely finished and lined with cat-tail down, and contained one egg. While I was examining the nest the female was right beside me, with her mouth open, "panting" from the noonday heat, which was very intense among the tall cat-tails, there being no breeze to moderate it. On May 23 the nest contained three eggs, and some Coot feathers had been added to the lining. The female had also begun incubating. On successive dates after that she became even tamer. I photographed her on the nest under great difficulty, due to the depth of the mud and the difficulty of obtaining sufficient light among such very tall cat-tails. June 3 was the last day on which I saw the female at the nest. June 7 she was nowhere to be seen and the eggs were cold. I fear that some accident befell her. I never saw the male nearer than 100 feet to the nest at any time. On June 14 something had broken two of the three eggs which I had left in the nest in the vain hope that the female might return or that the male might take charge of them. They contained rotten embryos. Something also happened to all the other nests discovered, so I had no opportunity of observing the young.

The worst enemies of this species appear to be eggers, who, while searching the marsh for larger eggs, destroy any small birds' eggs they come across.

The stomachs of two birds collected at Cartagena Lagoon in March and April and of one collected near Cape Rojo Lighthouse in April were examined. All of them contained exclusively animal matter. Items identified in the food of the Cartagena birds were: 5 ladybirds (*Hyperaspis apicalis*), 37.5 per cent; 1 large fleabeetle (*Haltica jamaicensis*), 2.5 per cent; 1 green Chrysomelid, 2.5 per cent; other Coleopterous fragments, 30 per cent; 6 ant pupæ, 1.5 per cent; 5 ants (*Prenolepsis* sp), 7.5 per cent; 1 Muscid fly, 2.5 per cent; 2 small Dipterous pupæ, 2.5 per cent. The Cape Rojo bird had eaten a large Notonectid, 90 per cent; and a small weevil, 1 per cent. The balance of the food in all the birds consisted of insects comminuted beyond identification.

Like most of the members of its family, this species appears to be in the main useful. It is a bird of both salt and fresh water swamps, though found to some extent at other places in the coastal lowlands. It is not specialized for marsh life, but seems to prefer the shelter offered by the marshes for breeding purposes, and the abundance of food there is also an attraction.

94. *DENDROICA ADELAIDAE* (Baird). Adelaide's Warbler. *Reinita.*

Adelaide's Warbler is the other warbler indigenous to Porto Rico. It is a characteristic species of the dry, brushy regions on the south side of the Island and of the limestone hills. At Cartagena Lagoon it is found only in the Varronia association, where it is quite common, though I have not located any nests there. I have observed it all along the south coast from Ponce to Boquerón, and in the limestone hills near Quebradillas on the north side. It is very active and feeds where the vegetation is dense. For that reason it is quite hard to observe, although it is not shy. The song of the male is a sudden trill or series of trills, increasing in rapidity, and with a rising inflection at the end. It might be likened to the syllables *Chip-prr-rr-rr-rr-chip-chí.* The males are very persistent singers, frequently being heard even in the middle of the day.

Apparently the birds nest in May. The only nest I found was on the very summit of Tinaja Hill. It was completed but did not yet contain eggs on May 6, 1924. It was built entirely of fine grass, and was placed about three feet above the ground in the croth of an organ-pipe cactus.

Two birds were collected at Cartagena Lagoon in May and September, and one at Guánica Lagoon in October. All three had eaten nothing but insects. Smooth Lepidopterous larvæ, ant pupæ, and a Pentatomid bug were noted in the Cartagena birds; and 6 Cicadellidæ; 1 Scarabeid beetle (*Ataenius stercorator*), and 1 Chrysomelid (*Lema* sp.) in the Guánica bird.

95. *DENDROICA CORONATA* (Linnaeus). Myrtle Warbler. *Reinita.*

The Myrtle Warbler is an uncommon migrant and a rare winter visitant at Cartagena Lagoon. It is very rare during the winter, and only slightly more common from February to April. It is a late arrival, none being noted before December 14, 1923, and my latest spring records are April 8, 1922, and April 1, 1924. While at Cartagena Lagoon it is found only in the Varronia Association. All my records for this species from other parts of the Island are from dry brushy regions, with the exception of one bird noted in a canefield near Mayagüez on March 17, 1924. The partiality of this species for dry brushy areas while on the Island is noteworthy.

96. *DENDROICA MAGNOLIA* (Wilson). Magnolia Warbler. *Reinita.*

The Magnolia Warbler is a rare winter visitant in Porto Rico. The only Cartagena Lagoon record I have is of a bird seen in the Bamboo Association on November 30, 1923. At Mayagüez I have records of a bird seen March 25, 26, 27, 28 and April 3, 1922, and of one on December 3, 1923.

97. *DENDROICA DISCOLOR* (Vieillot). Prairie Warbler *Remita.*

The Prairie Warbler is a rather common migrant at Cartagena Lagoon, occurring only in the Varronia association. Spring dates are February 6 to April 4, 1924, although in 1922 birds were seen as late as April 22. In 1924 the first fall birds arrived September 20. A few birds stay all winter in parts of Porto Rico, as I have noted them at Mayagüez right through the winter, and also one near Utuado on January 1, 1924. Near Mayagüez they are found mostly in the brushy growth just back of the beach, although they are found to some extent in the coffee *fincas.*

Two males collected at Cartagena Lagoon March 21 and April 4, 1924, were extremely fat. They had eaten 98 per cent of animal matter, among which were 1 Fulgorid, 2 deerflies (*Chrysops vittatus*), 1 Pentatomid bug, 1 small moth, and some beetle fragments (the latter forming 45 per cent of the stomachs' contents) were noted. A little white pithy matter totalling 2 per cent was found in one stomach, which was the only vegetable matter.

98. *SEIURUS AUROCAPILLUS* (Linnaeus). Oven-bird. *Pispita.* *Pispita dorada.*

The Oven-bird is a very rare migrant at Cartagena Lagoon, my only record being a bird observed April 18, 1924, in the Bamboo association. At Mayagüez it is a common winter visitant. It is found most commonly in the coffee *fincas.* In 1922 a pair spent the last part of the winter in our back dooryard. It was well shaded by orange and banana trees. The Oven-birds picked up scraps of food that were thrown to the chickens and became very tame They were not seen after April 20. In 1924 none were seen after April 10, and the first fall birds were noted on September 24. The familiar call note heard in the North is heard only when they first arrive in the fall. They are very silent during most of the time spent on the Island.

A male collected at Mayagüez December 21, 1923, had eaten 18 per cent of animal matter and 72 per cent of vegetable matter. A weevil and some other comminuted insects constituted the animal part, and some Guinea Grass (*Panicum maximum*) seeds and a little rubbish formed the vegetable part. Gravel to the extent of 15 per cent of the stomach contents was also eaten.

99. *SEIURUS NOVABORACENSIS NOVABORACENSIS* (Gmelin). Northern Water-thrush. *Pispita. Pispita de los manglares.*

The Northern Water-thrush is a common winter visitant at Cartagena Lagoon, but is commoner during the spring and fall migrations. My first fall record is September 3, 1924, and my latest spring record April 30, 1924. These birds are most commonly seen in the narrow strip of Persicarias fringing the rather steep south shore of the lagoon, frequently spreading out into the Varronias. They are also common along the quebrada in the Bamboo association and in the Tachuelo association, and they occasionally occur in other parts of the marsh. In other parts of the Island I have found this species in the mangroves swamps near Boquerón and Cape Rojo Lighthouse, and also on the seabeach near the latter place where there was a little scrubby vegetation. Their characteristic call notes are constantly uttered, but I have not heard their song in Porto Rico.

Four specimens were collected at Cartagena Lagoon (April 4, 8 and 11 and September 23, 1924) and one on the beach at Cape Rojo, near the lighthouse, on April 27, 1924. All but one of the April birds were extremely fat. The Cartagena birds had eaten 95 per cent of animal matter and 5 per cent of vegetable matter. Identified items in the vegetable matter were: 3 damselflies, 10 per cent; 20 large fleabeetles (*Haltica jamaicensis*), 19 per cent; 2 fleabeetles (*Systena basalis*), 1.3 per cent; Carabid beetles (*Stenous* sp.), 26.2 per cent; pupa of a Sesban weevil (*Tyloderma* sp.), 1.2 per cent; other Coleopterous fragments 5 per cent; 2 Noctuid caterpillars, 5 per cent; 1 Syrphid fly (*Volucella obesa*), 2 per cent; 3 caseworms (*Tineola uterella*), 6.1 per cent; 1 slug, 2.5 per cent. The vegetable matter (5 per cent) consisted of a few seeds, among which was one of some plant of the Composite family, probably *Pluckea purpurascens*. The stomach of the Cape Rojo bird was empty except for a small fragment of some beetle.

It thus appears that this species eats slightly more injurious than beneficial species, although Carabidæ form quite a large percentage of its food.

100. *SEIURUS MOTACILLA* (Vieillot). Louisiana Water-thrush. *Pispita. Pispita de los manglares.*

The Louisiana Water-thrush is a winter resident at Cartagena Lagoon, though much less common than S. n. novaboracensis. It is more common by the swiftly flowing streams than in other parts of the Island, although it is sometimes seen in the coastal mangrove swamps. While at Cartagena Lagoon it is found in the same regions as the Northern species. Last spring dates are April 10, 1924, and April 22, 1922, and my first fall record is September 6, 1924. No specimens were collected, so I can say nothing at first hand about the food habits of this species.

101. *GEOTHLYPIS TRICHAS BRACHIDACTYLA* (Swainson). Northern Yellowthroat. *Reinita.*

The only definite record for Porto Rico that I know of for the Northern Yellowthroat is of a male that I observed in the Bamboo association at Cartagena Lagoon on April 18, 1924. It was in a pile of bamboo brush near a pool of water. After I had observed it a few seconds it disappeared in the brush. I was hurrying to catch the only train of the day else I would have stopped to collect it. This record appears in the October, 1925, *Auk*.

102. *SETOPHAGA RUTICILLA* (Linnaeus). Redstart. *Reinita. Candelita.*

The Redstart is only a migrant at Cartagena Lagoon, though it is a winter resident in other parts of the Island. At the lagoon it is found only in the Bamboo association, where it is fairly common at times. I have records there from October 7 (1924) to December 22 (1923); and from April 1 to 22 (1924). At Mayagüez it is found all winter. My latest spring record for the Island is April 26, 1924, near Cape Rojo Lighthouse. In April a few Redstarts are singing.

The only bird collected at Cartagena Lagoon was a male on April 18, 1924. Its stomach contained animal matter exclusively. Small beetles formed 90 per cent, a weevil 1 per cent, a small ant 2 per cent, and some much-comminuted insect fragments 7 per cent.

103. *MIMUS POLYGLOTTOS ORPHEUS* (Linnaeus). Jamaican Mockingbird. *Ruiseñor.*

The Mockingbird is a common resident species at Cartagena Lagoon, living in the Varronia and Tachuelo associations, and sometimes feeding in the open-fields association. It is also common throughout the lowlands of Porto Rico, and in open places at higher elevations. It is most abundant on the south coast, seeming to prefer a semiarid climate, where it is most often found in brushy places. It is quite shy, and it is seldom possible to approach it very closely. The males sing from the tops of low trees, but they quickly hop out of sight when they realise they are watched. They sing throughout the year with the exception of the months of July and August. A female collected in August was molting badly. These birds are very poor mockers, in fact only once have I heard one imitate any other bird. One heard at Mayagüez on December 27, 1923, imitated an Ani very cleverly. There is much individual variation in the songs of this species. One bird which sang constantly near a hut in the hills between Mayagüez and Añasco in which I spent two months had a very distinctive song which might be likened to the syllables *Pea acre, pea acre, pea, pea, pea.* The call note is a sharp *tzeck.*

Apparently the nesting season extends from February to June. The nests are large affairs built of sticks and lined with grasses and other fine materials, placed in shrubs or shrubby trees at heights of eight to fifteen feet above the ground. Young birds are frequently noted in the summer months.

Two birds were collected at Cartagena Lagoon (August 13 and September 30, 1924). Animal matter formed 64.5 per cent of the food in these stomachs, and vegetable matter 35.5 per cent. Animal matter found consisted of 2 Geometrid caterpillars, 15 per cent; 1 Sphingid caterpillar, 15.5 per cent; 1 Noctuid caterpillar, 7.5 per cent; and 5 butterfly caterpillars, 49.5 per cent, making a total for Lepidopterous larvæ of 84.5 per cent of the animal matter. The other 15.5 per cent was formed by 2 slugs (15 per cent) and fragments of a tumble beetle (0.5 per cent). The vegetable matter consisted of 13 fruits of *Cordia* sp., 50 per cent, and some unidentified seeds. In the field I have observed one eating fresas (*Rubus* sp).

104. *MARGAROPS FUSCATUS FUSCATUS* (Vieillot). Pearly-eyed Thrasher. *Zorzal. Zorzal pardo.*

The Pearly-eyed Thrasher is an uncommon resident in the vicinity of Cartagena Lagoon. It is fairly common on Tinaja Hill, but at the lagoon is found only rather irregularly in the Bamboo association. It is quite similar to *Mimocichla* in form, though more robust and with larger feet. In flight it bears a slight resemblance to a pigeon, and the white tips of the tail feathers show conspicuously. While singing it remains concealed by the foliage. The song is very varied, but many of the notes are quite similar to those of *Mimocichla.* This species is found rather commonly in semiarid brushy regions along the south coast, where I have observed it from

Ensenada to Cape Rojo Lighthouse. I have also heard one several times on a hill near Mayagüez.

A male collected at Cartagena Lagoon on September 30, 1924, was molting badly. It had eaten 40 per cent of animal matter and 60 per cent of vegetable matter. The animal matter consisted of fragments of a large brown and green Cerambycid beetle, 60 per cent, and a smooth caterpillar, 40 per cent. The vegetable matter consisted of fruit pulp.

105. *MIMOCICHLA ARDOSIACEA PORTORICENSIS* (Bryant). Porto Rican Thrush. *Zorzal. Zorzal de patas coloradas.*

The Porto Rican Thrush is a rare resident at Cartagena Lagoon, being found in the Bamboo association. Once I observed a bird in the Varronias. In the more wooded parts of the Island this is a common species. It feeds almost exclusively upon the ground, but when alarmed flies up into the trees, and it also perches in trees to sing, and the nests are placed in trees. Rustling sounds in the leaves are frequently found to have been produced by the scratching of a Zorzal, for in Porto Rico it takes the place of the Towhees and White-throats of the North.

These Thrushes begin singing at the first streak of dawn and sing until about 7 a. m. Their song is quite similar to that of the Robin, but is less varied and the tones are not so rich. The notes are also more disconnected. In other words, it sounds like a crude imitation of a Robin's song. Another note heard at times is a *wicky, wicky, wicky, wicker* sound similar to that made by the Sparrow Hawk.

Birds were observed gathering nest material as early as January 23, 1924, and many were seen carrying it in February and March. Badly molting birds, some without tail feathers, were noted in June, while a female collected in September appeared to be nearly ready to breed, so there is a possibility that some birds raise a second brood. The only nest I actually observed was found on March 30, 1924, at Mayagüez. It was composed of shreds of bark, fine twigs, a small piece of partly rotted burlap, some string, pieces of fern leaf, and three feathers of domestic poultry. It was lined with shredded inner bark. It was placed among some upright shoots growing from a branch of a Guanábano tree (*Anona muricata*) at a height of nine feet from the ground. Some *Allamanda hendersonii* vines also partly concealed the nest. It was somewhat oval in shape. The inside diameters of the nest were 4.5 and 3 inches, and the outside ones 6 and 4 inches. When the nest was discovered the female was just laying the first egg. She never returned to lay another egg, so after some time I collected the one egg. It has a putty-colored background, and is heavily and evenly mottled with rufous-brown, and is decidedly pointed at one end. Its measurements are 33 × 22 millimeters.

A female collected in a coffee *finca* near Mayagües September 25, 1924, had eaten 85 per cent of animal matter and 15 per cent of vegetable matter. A large Tenebrionid beetle formed 35 per cent of the animal matter, and 6 white grubs (Phyllophaga vandinei) 60 per cent. The vegetable matter consisted of angular seeds, apparently of some pulpy fruit. A bird with the habits of this species has great possibilities in obtaining injurious ground-inhabiting insects found in more or less wooded regions, such as coffee *fincas* and orchards. As there is no other Porto Rican bird with very similar habits, the Zorzal should by all means be encouraged.

SUMMARY

A total of 105 species of birds are found at Cartagena Lagoon and its immediate vicinity. Of these, 42 are migrants from North America. Another 42 species breed there either regularly or occasionally. Two of these (*Progne dominicensis* and *Vireosylva c. calidris*) breed in Porto Rico but winter in South America, and it is possible that a third species (*Himantopus mexicanus*) does likewise. Twenty-one species come to the lagoon only to feed, though breeding in other parts of the Island.

An average of 36 species of birds per day were recorded at the lagoon. The largest day's list was 48 species on April 11, 1924, and the smallest 26 species on August 13, 1924 (when the lagoon was nearly dry). The largest list in the fall was 45 species on September 30, 1924.

Of the 42 species of birds breeding at or in the immediate vicinity of the lagoon, 19 might be called typical lagoon species. Nine of these are entirely dependent upon the marsh for food and shelter, while 10 visit it primarily for food. Three of the ten, namely, *Poecilonetta b. bahamensis, Butorides virescens maculatus* and *Oxyechus vociferus rubidus,* visit it because they show a preference for marsh conditions and aquatic food. The other seven occur at the lagoon because of the abundance of food found there rather than on account of any special preference for marsh conditions or aquatic food. In this class I would include *Zenaida zenaida lucida, Chaemepelia passerina trochila, Crotophaga ani, Tyrannus d. dominicensis, Agelaius xanthomus, Holoquiscalus niger brachypterus* and *Dendroica petechia bartholomica.* Although some of these birds, namely, *Zenaida zenaida lucida, Holoquiscalus n. brachypterus* and *Dendroica p. bartholomica,* nest more or less regularly in the marsh, there are no birds which appear to visit the marsh primarily for shelter.

Of the 9 species which are entirely dependant upon the marsh for food and shelter, *Colymbus d. dominicus* is almost entirely restricted to the cat-tail zone, and *Podilymbus podiceps antillarum* to the open-water association. *Erismatura alleni* prefers the sedge and cat-tail zones for nesting. *Ixobrychus e. exilis* is entirely restricted to the cat-tails for breeding. *Porzana flaviventris* is found chiefly among the cat-tails and sedges, but its nesting habits are unknown. *Gallinula chloropus portoricensis* and *Fulica caribaea* *major* are chiefly birds of the cat-tail, sedge and grass associations, while *Ionornis martinicus* prefers the cat-tails for nesting. *Himantopus mexicanus* prefers the grass association, but it is very adaptable, and establishes itself in almost any zone when it is molested in another.

CONCLUSION

Cartagena Lagoon is to-day the most important breeding ground for resident waterfowl as well as the most important refuge for migrant water birds in Porto Rico. It also supplies food for thousands of other birds which are not primarily marsh birds. There is probably no other spot on the Island where so large an assemblage of birds of so many species can be found. It will be a sad day indeed for the bird life of Porto Rico when the lagoon is drained. It will probably mean the extermination of certain species as far as Porto Rico is concerned, and a great diminution in the numbers of others. Many of these birds are of great value, either to the agriculturist or to the sportman. It would be a great economic asset to the people of Porto Rico if, before it is drained, the lagoon could be obtained either as a private, or preferably as a government wild-life preserve where the birds would be strictly protected while breeding, and hunting carefully regulated and supervised at other seasons.

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APPENDIX

To Vol. X, No. 1, of the Journal of the Department of Agriculture of Porto Rico, containing legislation in force regarding the protection of birds in Porto Rico, Compiled by F. A. López Dominguez, Director, Insular Experiment Station, and editor of the Journal. (See footnote, page 25, Vol. X, No. 1, of this Journal.)

ACT 45

TO PROVIDE FOR THE DEVELOPMENT AND PROTECTION OF AGRICULTURE, THE CREATION OF A BOARD OF COMMISSIONERS OF AGRICULTURE, DEFINING THEIR POWERS AND DUTIES; TO AMEND AN ACT ENTITLED "AN ACT TO PREVENT THE INTRODUCTION INTO PORTO RICO OF PLANT AND INSECT DISEASES, AND PESTS, AND FOR OTHER PURPOSES", APPROVED SEPTEMBER 3, 1910, TO PROVIDE FOR THE INTRODUCTION AND PROTECTION OF BIRDS BENEFICIAL TO AGRICULTURE, FIXING PENALTIES FOR THE DESTRUCTION OF SAME; MAKING AN APPROPRIATION TO CARRY OUT ITS PROVISIONS, AND FOR OTHER PURPOSES APPROVED MARCH 9, 1911

Section 5.—That it shall devolve upon the board:

* * * * * * *

Fifth: To prepare, print, publish, and furnish on request, a list of birds beneficial to Agriculture, as provided for in Section 6 of this Act; the Board having the right to amend said lists from time to time.

Section 6.—That the act of seizing, killing, destroying or keeping in one's possession, any bird beneficial to agriculture, be and is hereby declared to be unlawful. Whosoever seizes, kills, destroys, or keeps in his possession any bird beneficial to agriculture shall be guilty of a misdemeanor and punished therefor with a fine of not less than five nor more than twenty-five dollars or with imprisonment for not more than ten days, or with both penalties. The board shall prepare, print, publish and furnish on request, a list of birds which in their opinion are beneficial to agriculture, and any bird comprised in said list shall be conclusively considered as beneficial to agriculture for the purpose of this Act.

CHAPTER XIV, REVISED STATUTES AND CODES OF PORTO RICO, ISSUED MARCH 1911

Section 5969.—Every person who, within any public park, plaza or highway, kills, wounds, or traps any bird, or destroys any bird's nest, or removes any eggs or young birds from any nest, is guilty of a misdemeanor.

ACT 60

TO PROVIDE A GAME LAW

Be it enacted by the Legislative Assembly of Porto Rico:

CHAPTER I

CLASSIFICATION OF ANIMALS

Section 1.—Wild animals found in public lands, as well as those found in private lands, are hereby declared to be the property of The People of Porto

Rico. The wild goat, the wild hog, the rat and the mangouste or pharaon rat are the only wild quadrupeds that may be hunted in Porto Rico. In the appendix attached hereto, which shall form part of this Act, there will be found a classified and specified list of the animals that may be hunted in the Island which, with the exception above stated, belong to the genus of birds.

CHAPTER II

HUNTING RIGHT

Section 2.—The word "hunt" shall be taken to include all legal means of looking for, pursuing, harassing, catching or killing all wild animals or animals which may have become wild.

Section 3.—All persons of legal age, possessing a hunting certificate, shall have the right to hunt, but shall exercise such right subject to the provisions of this Act.

Section 4.—The right to hunt may be exercised on lands of The People of Porto Rico without the necessity of obtaining a permit therefor, provided they are not closed for that purpose or the entrance thereto prohibited by competent authority. This prohibition shall be advertised by various means, such as posters placed at conspicuous points in the boundaries of the lands where hunting shall have been prohibited

Section 5.—The right to hunt may also be exercised without previous permit, on private lands not under cultivation which are not visibly enclosed or bounded or not having signs prohibiting hunting in the same manner and form prescribed in the preceding section. In lands provided with these requirements only the owners, lessees and judicial administrators thereof, or the persons authorized by them, shall have the right to hunt provided they possess the necessary hunting license.

Section 6.—For the purposes of this Act the words "enclosed lands" shall be taken to mean all those having any of the different classes of fences used in Porto Rico, and by "bounded lands" shall be understood all those whose boundaries are marked by permanent stone, concrete, masonry or wooden monuments. Game lands whose owners or lessees do not use the game for selling or other commercial purposes shall not be assessed as such

Section 7.—A hunter shooting from game lands where hunting is permitted and wounding a bird or animal which falls or enters into private property shall have right to the same, but in order to recover it he shall first obtain due permission from the owner or lessee of the property if the same be enclosed by any of the means recognized by this Act. In case the hunter is authorized to enter the property he shall at all times be responsible for damages caused to crops or property.[1]

CHAPTER III

EXERCISE OF THE RIGHT TO HUNT

Section 8.—Hunting shall be absolutely prohibited during the closed seasons which shall be as follows:

(*a*) Wild pigeons of all kinds: From the first day of January until the fifteenth of July.

(*b*) For ducks: From the first day of May until the thirty first of December.

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[1] The equivalent of the words "or property' does not appear in Spanish text.

(c) For the birds of the *Rallidæ* family (American coot, gallinule, etc.): From the first day of December until the last day of February.

(d) For all other birds and mammiferous animals: From the first day of February until the thirtieth day of June.

Section 9.—At no time shall the birds included in list number 2 of the appendix to this Act either be killed or caught. In accordance with the provisions of section 5 hereof, domestic pigeons may only be caught or killed by their owner or by virtue of written authorization from him. Carrier pigeons shall in no case either be caught or killed.

Section 10.—The firing of shotguns and other firearms at a distance of less than one kilometer from any town is hereby prohibited.

Section 11.—The owners or lessees of rural properties may install in them all kinds of devices for the destruction of animals comprised in list number 3 of the appendix; but at no time shall such device be installed in public roads or trails.

Section 12.—The handling or sale of game animals during the closed seasons specified in section 8 hereof is absolutely forbidden.

Section 13.—The closed seasons shall be advertised each year in the newspapers of larger circulation in the Island. The *alcaldes* shall make known its provisions by means of posters and placards posted in the town and *barrios*. The Secretary of Porto Rico shall see that this requirement is complied with.

Section 14.—Any person destroying the nest of game birds or those of birds comprised in list number 2 of the appendix hereto shall be guilty of a violation of this Act and shall be liable to the penalties fixed herein.

Section 15.—It shall be the duty of the police and employees of the Irrigation Service at the lakes and canals of the Irrigation Service to denounce any violation of this Act that they might see or which might come to their knowledge. Any citizen will also have the right to denounce the violators of the same.

CHAPTER IV

HUNTING AND FIREARMS LICENSES—PROCEDURE.

Section 16.—No person shall have the right to carry shotguns or hunt unless he has first obtained the corresponding license, which license shall be issued by the Secretary of Porto Rico subject to the provisions of law. Said license shall be good for a term of one year from the date of issuance and may be renewed on petition of the interested party upon payment of the fee.

Section 17.—The police shall require the presentation of the hunting license and of the permit to carry shotguns, and upon failure of the huntsman or huntsmen to exhibit same his or their arms shall be confiscated, but the same shall be returned to the respective owners if within a term of eight days they should present the license issued on a previous date to that of the confiscation.

Section 18.—Upon the expiration of the term of eight days, should the above condition not have been complied with said arms shall definitely be confiscated and sold by public bids.

CHAPTER V

VIOLATIONS—PENALTIES

Section 19.—Any wilful violation of the provisions of this Act shall be deemed as a misdemeanor and shall be punished by fine of not less than twenty-five dollars or imprisonment of not to exceed thirty days.

Section 20.—The fee for the hunting license shall be of ten dollars per annum and shall be payable in internal-revenue stamps. The authorization to which this section refers shall include all kinds of shotguns of whatever caliber and all other arms the use of which may be adapted to hunting.

Section 21.—All laws or parts of laws in conflict herewith are hereby repealed.

Section 22.—This Act shall take effect from and after the first day of June, nineteen hundred and sixteen.

APPENDIX

List Number 1

GAME BIRDS

1st order: *Columba*
Unique family: *Columbidæ*

Domestic dove
Turtle dove
Savage partridge
Partridge of Martinica
Small turtle dove
Cinerious pigeon of savanna
Wood pigeon
White-crowned pigeon
Portorican dove

2d order: *Cranes*
Family *rallidæ*

American coot
Florida gallinula
Purple gallinule
Sora rail
Yellow rail
Jacana
Limpkin
Clapper rail

3d order
Family *scolopacidæ*
Snipe

4th order
Family *adeidæ*

Yellow-crowned night heron
Black-crowned night

5th order: *Palmipedæ*
Family *anatidæ*

Goose
Snow goose
Tree duck
Small spoon duck
Domestic duck
Long-neck duck
Florida goose or of border
Ruddy duck
Green-winged teal duck
Black-streak duck or dominic
Rustic duck of the middle
Dark rustic duck

6th order
Family *laridæ*

Sea gull
Exotic sea gull
Gull of Paradise
Antilles gull
Royal gull
Sharp-billed gull
Black sea gull
Dark sea gull

7th order
Family *colymbidæ*

Red-billed grebe
Least grebe

LIST NUMBER 2

BIRDS USEFUL TO AGRICULTURE

1st family: *Lanidæ*

Jamaican vireo
Látimer vireo

2d family: *Turdidæ*

Wood thrush
Pearly-eyed thrasher
Portorican thrush

4th order
Family *ardeidæ*

Great blue heron
Snowy heron
Agret royal
Great white heron
Reddish egret
Little blue heron
Spotted heron
Little green heron
Least bittern

3d family: *Sylvidæ*

Maryland yellow throat
Yellow warbler
Black polt warbler
Black and white warbler
Palm warbler
Prairie warbler
Yellow-throated blue warbler
Adelaide's warbler
Black-throated blue warbler
Mirtle warbler
Magnolia warbler
Cape May warbler
Ovenbird
Water thrush
Parula warbler
Worm-eating warbler
American red start

4th family: *Tyranidæ*

Gray kingbird
Portorican Petchary
Portorican flycatcher
Portorican wood pevee

5th family: *Tanagridæ*

Portorican euphonia
Portorican tanager
Portorican spindalis

6th family: *Fringillidæ*

Portorican glod finch
Antillean grasshopper sparrow
Hooded weaber-finch
Scarlet-cheeked weaber-finch
Carib grassquit
Bryant's grassquit

7th family: *Icteridæ*

Fawny-shouldered blackbird
Portorican grackle
Troupial
Portorican oriole, calendar

8th family: *Corvidæ*
Portorican crow

9th family: *Dacnididæ*
Portorican bananaquit

10th family: *Alcyonidæ*
Portorican tody

11th family: *Hirundinidæ*

Church swallow
Rustic swallow
Cave swallow
Green blue swallow
Bank swallow

12th family: *Cipselidæ*
Black swift

13th family: *Caprimulgidæ*

Nighthawk
Coat sucker of Carolina

14th family: *Piscidæ*
Woodpecker

15th family: *Cuculidæ*

Ani
Bird booby larger
Mangrove cuckoo
Black billed cuckoo

1st family: *Falconidæ*
Small falcon

List Number 3

BIRDS PREJUDICIAL TO AGRICULTURE

5th order—Rapacious of the day
1st family: *Falconidæ*

Fish hawk or osprey
Red-tailed hawk
Pennsylvania falcon
Barn owl

2d family: *Strigidæ*
Rapacious of the night

Owl of savanna or coruja
Common owl.

Approved April 13, 1916.

ACT 22

TO PROVIDE A FOREST SERVICE IN PORTO RICO

Approved November 22, 1917

BIRD REFUGES

Section 5.—That the Governor may, with the advice of the Commissioner, by executive order or proclamation declare any or all of the Insular Public Forests to be a bird refuge for any game or other kind of bird or birds which it may be seen desirable to especially foster, encourage and protect. It shall thereafter, and as long as any such refuge be and is continued, be the duty of the Commissioner and all the Service subordinates to exercise special vigilance in the enforcement of any and all laws or the rules and regulations of the Commissioner supplementary thereto pertaining to the protection of the bird or birds thereon.

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[1] As of date of issue.

[2] Vacant.

EPIPHYTIC ORCHIDS A SERIOUS PEST ON CITRUS TREES

MELVILLE T. COOK

Epiphytic orchids have been frequently reported as growing on citrus trees but the writer does not know of any record of their occurring in sufficient abundance to be destructive. In July 1925, the attention of the writer was called to a citrus plantation between the Carolina Road and Trujillo Alto in which orchids have appeared in such great abundance as to be very destructive. Since that time other cases have been reported.

Two different species of orchid (*Ionopsis utricularioides* (Sw.) Lindl. and *Leochilus labiatus* Kuntze.) were found to be active agents in killing the branches of the trees, but *I. utricularioides* was by far of the greatest importance. Therefore, the greater part of this paper will be devoted to his species. The largest of these plants (Fig. 1) did not have more than six leaves, the largest leaf was nine inches in length and the longest flower shoot was about two feet in length. However, the plants begin blooming when very small. Many plants with leaves a little more than one inch in length produced flower shoots about four inches in length and a few flowers. The roots varied from a few in number to thick masses. A young plant (Fig. 2) is usually supported by three or four roots which grow in any direction for a distance of three or four feet or even more but adhere closely to the host plant. These roots branch rather sparingly, but as the plant increases in size and age new roots are produced which mingle with roots of other plants until the branch is almost completely encrusted for a considerable distance (Fig. 3). As the plants increase in age aerial roots (Figs. 4 and 5) are produced in very great abundance. These aerial roots frequently become attached to neighboring branches and are produced in such great abundance as to give the appearance of a mass of Florida Moss. The aerial roots are not different from those attached to the branches. They are aerial simply because they have not come in contact with any resistant object. If one of these roots comes in contact with a stem or leaf within a reasonable time, they immediately become attached. They frequently become attached to the leaves of the orchid from which they were developed.

The infections vary from a single small plant to dense masses of plants of various ages and sizes. The writer counted as many as twenty plants within a distance of twelve inches. The plants were also found clustered in masses (Fig. 5). A careful examination indicated that these plants came from seeds. When carefully dissected out, it was evident that each plant had its own root system. This had to be determined almost entirely from the study of very small plants because plants of one inch in length usually produced such lengthy root systems that it was difficult to follow them. The encrustation of roots on the surface of a branch afforded a most excellent place for the lodgement of seeds and thus gave rise to the great number of plants of various ages and sizes within a small area. The writer failed to find a single case in which two plants had a united root system. The roots when dry are very grey but many of them develop a light green color when young and in the presence of moisture.

The infections are most abundant in reduced sunlight and moisture but none were found in dense shade and excessive moisture. The infections usually start by the development of one or more seedlings on a branch or twig where it is well shaded. When the plant is ready to produce fruit, the flowering shoots grow upwards and into the sunlight. Small plants, producing short flowering shoots previously referred to are usually exposed to the sun as a result of the dying of the leaves of the host. The larger plants produce longer flowering shoots and more flowers, the flowering shoots always carrying the flowers into the sunlight. Although the plants start and develop in the shade and are seldom exposed to the direct sun light, except as a result of the dying of the leaves of the host, the flowers are always borne in the direct sunlight. It, therefore, appears that the strong sunlight may stimulate flowering. The plants fruit very freely and produce enormous numbers of very small seeds. These seeds are so small and light that they are easily carried by the wind to the same or neighboring trees, where some few of them germinate and give rise to new plants. Naturally the greater the distance from the point of origin the more scattered the new infections. It was very easy to locate these original infections and to trace the new infections from these centers.

The effects of the Orchids on the host plant was that of strangulation (Figs. 2–6). The roots grow very rapidly and increase with the number and age of the plants and practically cover the entire surface of the branch for a considerable distance. The infected branches were eventually killed. Sometimes branches as much as three inches in diameter were killed. The killing of these branches very naturally destroyed the symmetry of the trees, gradually weakened them, reduced production and eventually killed them. The rapid spread of this pest was a surprise to the writer, who visited this plantation thirteen months previous to the discovery of this outbreak.

L. labiatus (Figs. 7 and 8) is a very much smaller plant, was much less abundant and much less destructive. There was no evidence that any branches more than three-fourths of an inch in diameter had been killed by this species. It appeared that this species was more tolerant to sunlight than *I. utricularioides.*

CONTROL

The control of these pests is comparatively simple. It consists in the removal of the plants so far as possible and in some cases the removal of heavily infected branches. Since the plants always start from seeds and not from the branching root systems, it is not necessary to remove all the roots. It is advisable to take the above precautions previous to spraying the trees, since the spraying fluids may kill some of the seeds and some of the very small plants which have been overlooked.

EXPLANATION OF PLATES

Figure 1: *Ionopsis utricularioides*, showing flowers, seeds pods and roots attached to the plant from which they were developed.
Figure 2: Young plants on a grapefruit branch.
Figure 3: Numerous small plants with well-advanced root systems on a grapefruit branch.
Figure 4: A number of plants on a dead branch. Also shows aerial roots.
Figure 5: Same as 4.
Figure 6: A number of young plants on a branch which is still alive.
Figures 7 and 8· *L. labiatus.*

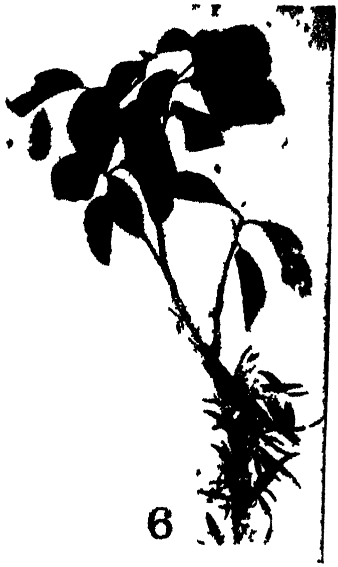
1

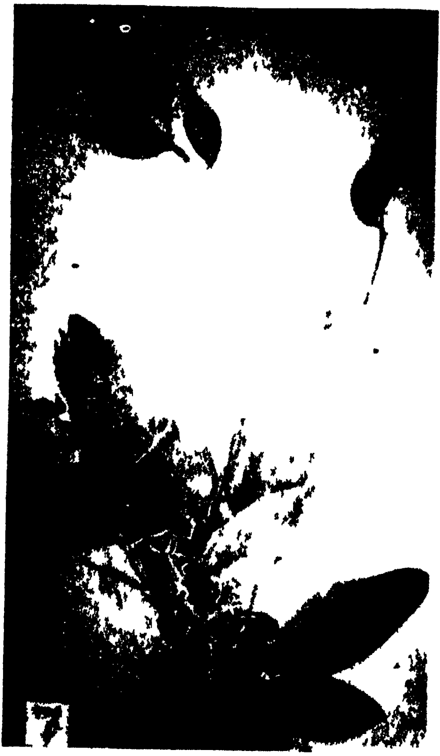
3

4

2

FIGURE 1.—*Ionopsis utricularioides* showing flowers, seed pods and roots attached to the seed plants from which they were developed.
FIGURE 2.—Young plants on a grapefruit [illegible]





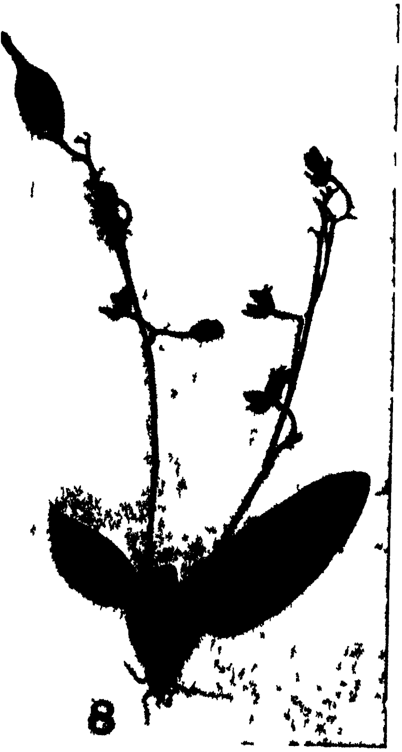


FIGURE 5.—Same as 4.
FIGURE 6.—A number of young plants on a branch which is still alive.
FIGURES 7 AND 8.—*L. labiatus*.

MYCOLOGICAL NOTES I[1]

RAFAEL A. TORO

(With one plate and one figure on the text)

The purpose of these notes is to present the results of the studies of the mycological flora of the Island of Porto Rico. The bulk of the literature already in existence on this subject contains several disagreements regarding the identity of some of the forms studied, and makes necessary a detailed and comprehensive revision of some of the groups.

The study of the tropical flora has been for a long time a subject of interest to those engaged in botanical classification of phanerogams, although, from the start, some cryptograms were incidentally collected and studied. The fungi collected in Porto Rico by P. Sintenis in 1881 were studied by Bresadola, Hennings and Magnus (Eng. Bot. Jahr. **17**^{5}: 489–501. 1893.) and recorded by Stevenson (Journ. Dept. Agric. Porto Rico **2**^{3}: 125–264. 1918.). Those collected by C. Schwanecke in 1846 were studied by Klotsch (Linnea **25**: 364–366. 1852.) and also recorded by Stevenson. We find in Stevenson's paper a record of only one of the fungi collected by Bertero in 1818. This fungus was described by Léveillé (Ann. Sci. Nat. **3**^{2}: 177. 1844.) under the name *Heliomyces berteroi* sp. nov. and was restudied and transferred by Murrill (N. Am. Fl. **9**^{4}: 267. 1913.) to *Marasmius berteroi* (Lev.) comb. nov. However, other fungi were also collected by Bertero and described by Montagne (Ann. Sci. Nat. **8**^{2}: 345–470. 1837.) and Léviellé (Ann. Sci Nat. **3**^{8}: 38: 77. 1845.) but not recorded by Stevenson. Montagne is, apparently, the first scientist to describe a fungus from Porto Rico. By way of introduction to these notes and as a matter of historical interest in mycology a presentation is here given of this description by Montagne:

"36. *Dothidea* (Asteroma) *Eugeniae* (Montag. mass.); amphigena, maculaeformis, centro opaca atra fibrillis ramoso-pinnatis, ramis patentibus in ambitu radiata, cellulis confertis minimis collapsis ostiolo instructis.

"hab. in foliis vivis cojusdam Eugeniae speciei in Porto Rico a Bertero et mecum sub nomine *Depateae eugeniae* a Balbisio communicata.

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[1] The writer wishes to acknowledge his obligations to Dr F. J. Seaver of the New York Botanical Garden for the facilities rendered during the writer's stay at that Institution and to Dr. Mel T. Cook for reading and correction of the manuscript.

"Elegans uti sunt pleraeque species hujus tribus. Maculae amphigeneae, variae amplitudinis, confluentes, saepius minimae, 1-2 lineas latae, centro opacae, ambitu fibrillis tenuissimis atriculatis ramoso-pinnatis, ramis alternis decrescentibus radiatae. Cellulae praesertim in centro macularum confertae, sed tamen distinctae, minutissimae, collapsae, pezizaeformis, eumorphae, ostiolo sub vitris augentibus tantum conspicuo instructae et sat similes peritheciis *Sphaeria complanatae* Tode, a quibus mole solum primo intuitu recedunt."

This fungus is also recorded by Saccardo (Syll. Fung. **1**: 49. 1882.) in his section *Asteridium* under the name of *Asterina eugeniae* Mont. It can not be an *Asterina* since Saccardo states in the description that the spores are three-septate. Theissen (Abh K. K. Zoo-Bot. Ges. Wien 7^3: 25. 1913.) also excludes the species from *Asterina* Lév because "Nach der Beschreibung sind die Sporen vierzellig". The writer examined a specimen from South America, deposited in the herbarium of the New York Botanical Garden and labelled *Dothidea Eugeniae* Mont., and found that there are no asci or spores on the fungus

Léveille describes two other fungi from Bertero's collection: *Sphaeria ecastophylli* sp. nov. on leaves of *Pterocarpus Ecastophyllum* and *Stilbum berteroi* sp. nov. on dead twigs. The first species was transferred by Saccardo (Syll. Fung. **1**: 446. 1882.) to *Physalospora Ecastophylli* (Lév.) The other species is still known under its original name. In his paper, Lévielle reports for the first time from the Island, *Meliola amphitricha* Fr. on leaves of *Aralia arborea.* This fungus may be the same as *Meliola araliae* collected in 1884 in Porto Rico on leaves of *Dendropanax arboreum* (L.) Dcne. y Pl. and reported by Stevens (Illinois Biol Monog. **2**: 505. 1916.).

1. Calothyrium Ingae Ryan.

The genus *Calothyrium* was established by Theissen (Ann. Myc. **10**: 160. 1912.) to include those species formerly assigned to *Asterina* Lév. having hyaline spores and mycelium devoid of hyphopodia. For the brown-spored forms the new genus *Asterinella* Th. was also proposed.

According to Arnaud (Les Asterinées **1**: 150. 1918.) the generic characters of *Microthyrium* Desm. were not well delimited. He found that the type-species, *M. microscopicum* Desm., is provided with superficial mycelium and resembles in general characters *Asterinella Puiggarii* (Speg.) Th. For this reason he amended the description of *Microthyrium* Desm., including among its characters the presence of superficial mycelium. The writer examined at the New York Botanical Garden a specimen labelled "*Microthyrium* *microscopicum* Desm". (Rab. & Wint. F. Europ. No. *2943*) and found that it has a very scanty superficial mycelium. Undoubtedly the genera *Calothyrium* Th. and *Microthyrium* Desm. are the same, while *Asterinella* Th. differs from either only in having colored spores. The genus *Calothyrium* Th. then becomes a synonym of *Microthyrium* (Desm.) Arnaud. Therefore, *Calothyrium ingae* Ryan becomes **Microthyrium Ingae** (Ryan) comb. nov.

On leaves of *Inga Inga* (L.) Britton. Porto Rico Fungi (Stevens). *No data.*

Spots none; colonies more or less circular, 5–10 mm. in diameter, membranous, black at the center, pale toward the edges; mycelium without hyphopodia, 3u. in diameter, straight, rarely anastomosing, light brown, septate; 90–110u. in diameter, astomous at first, ostiolate at maturity and dehiscing by desintegration of the cell walls, fuliginous, coriaceous, finely denticulate at the borders, prosenquimatous-radial, with thin, scarcely septate straight threads; asci oval-obovate, 14–18 X 14u., 8–pored, thick-walled and roundish at the upper portion sub-cuneiform at the lower and terminating in a thick, short pedicel; spores inordinate, cylindric-fusoid, 10–12 X 2–3u., 1-septate, the superior cell obtuse, sub-globose, the inferior acute, slightly constricted, hyaline; paraphyses filiform, mucilaginous.

C. Hippocrateæ Ryan may, according to the description, also belong to *Microthyrium* Desm. Since no material of this fungus has been available it is temporaly left under the former.

2. Microthyrium Psychotriae (Ryan) comb. nov.

The fungus *Calothyrium Psychotriæ* Ryan is also a *Microthyrium*. It forms no spots on the leaves but the subiculum consists of rather irregular, black crusts 2–5 mm. in diameter: the thiriothecia are 110–115u. in diameter, opaque-fimbriate, provided with ostiolo but dehiscing by desintegration of the radiate hyphæ which make up the perithecial elements; the mycelium is brown, 4–6u. thick, closely septate and nearly straight; the asci round, sessile, the upper portion very thick-walled, the lower thinner, 12–20u. in diameter, 8–spored, spores inordinate, elliptical, 2–celled, 5–7 X 2–3u., hyaline (Plate I, Figs. 4 & 5.).

On leaves of *Psychotria* sp. Porto Rico Fungi (Stevens) No. *6662.*

3. Lembosia microspora Chardón and Morenoella portoricensis Speg.

The genus *Lembosia* Lév. differs from *Morenoella* Speg. in having asci provided with paraphyses. The descriptions of *Lembosia microspora* Chardón (Mycologia **13**: 282. 1921.) and of *Moronoella portoricensis* Speg. (Bol. Acad. Nac. Ci. Córdoba **26**: 343. 1923), however, state that paraphyses are present in both species. The writer has examined several specimens of these two fungi and has found that the presence or absence of paraphyses is a very unstable character on which to determine the generic position of these species. According to the stage of maturity of the fungus, one will find sometimes distinct, sometimes few, or sometimes no paraphyses. The same has been found to apply to genera which are differentiated by their variations in structure of the free mycelium, for instance, as to the presence or absence of mycelial setæ or hyphopodia. So differs *Irene* Th. & Syd. from *Meliola* Fr. In *Irene* the mycelial setæ are wanting while they are present in *Meliola*. But from the examination of fresh material in the tropics the writer is convinced that *Irene* species with mycelial structures resembling setæ may also occur as *Meliola* with typical setæ, and vice versa, depending upon weather conditions, character of the host and stage of development of the fungus. Such genera, and many others, therefore, have very low value, but they considerably increase the already existing uncertainty and will frequently cause errors. It would be much better and more in accordance with natural conditions if such genera would only be considered as sub-genera. The writer (Mycologia **17**: 131–147. 1925.) recognized the genus *Irene* Th & Syd. as having well-defined characters, but only forms which do not show traces of typical setæ and have no mycelial structures resembling them, are considered. However, after more extensive studies it may possibly be found that even the complete absence of setæ is not a stable character, in which case it will be necessary to consider the genus as a section of the older genus *Meliola* Fr. The same may be applied to *Appendiculella* v. Höhnel, which differs from *Meliola* Fr. in the presence of vermiform perithecial appendages.

In his description of *Lembosia microspora,* Chardón makes the statement that hyphopodia are absent. However, upon re-examination of his type and other material it has been found that there are very distinct hyphopodia on the mycelium, although sometimes these are wholly absent. It was also noticed that these hyphopodia can be very easily mistaken for the basal cells of broken mycelial hyphæ which remain attached after the rest of the hyphæ have been separated. They are cylindric, 1-celled, pointed toward the ends and of the same color as the mycelium.

From the studies of the type-materials of *Lembosia microspora* Chardón and of *Morenoella portoricensis* Speg., the writer found that the dimensions of the different elements overlap and that there is no difference between the species. Also since they have the same general characteristic and occur on the same host there is no doubt that we are dealing with the same fungus in both cases. The name given by Chardón must be retained as valid for reason of priority, but the description needs to be emended.

LEMBOSIA MICROSPORA (Chardón) char. emend.

Lembosia microspora Chardón, Mycología **13**: 282. 1921.

Morenoella portoricensis Speg., Bol. Acad. Nac. Ci. Córdoba **26**: 343. 1923.

Echidnodes microspora (Chardón) Seaver & Toro. Sci. Surv. Porto Rico **8**: 41. 1926.

Spots none; colonies amphigenous; mycelium widely spreading, septate, 3–4u. in diameter, light-brown, branched, anastomosing; hyphopodia straight-cylindric or sub-ampulliform, small, 1-celled; thyriothecia scattered, black, often curved, 200–800 × 100–200u., asci obovate-ellipsoidal, 8-spored, 18–25 × 15–20u.; spores inordinate, 1-septate, constricted at septum, 10–15 × 4–5u., hyaline at first, becoming dark-brown with age; pseudoparaphyses present.

On leaves of *Ocotea leucoxylon* (Sw.) Mez. Cornell University Explorations of Porto Rico (Whetzel & Olive) *621* (Type of Chardón's species); Porto Rican Fungi (Stevens) *7563*, *4762*, *8459*, *9133* (Type of Spegazzini's species according to Ryan, Mycologia **16**: 193. 1924.), *1739*, *9436*, *9122*, *7319*, (Deposited in herbarium New York Botanical Garden).

Colonies thinly diffuse, more or less round, 5–20 mm. in diameter; mycelium thin, 3–4u. in diameter, straight, frequently anastomosing and at right angles to the hyphæ, light-brown, septate; hyphopodia numerous, generally opposite, at right angles to the mycelial hyphæ, cylindric and pointed toward the ends, 8–12 × 3–4u., 1-celled, light-brown; thiriothecia linear, 200–800 × 100–200u. scattered, dehiscing by a longitudinal slit, black, borders fimbriate, of thin, 2–2.5u. thick, light-brown hyphæ; asci obovate-ellipsoidal, 18–25 × 15–20u., thick-walled at the upper portion, thinner at the lower, 8-spored; spores inordinate, cylindric, 10–15 × 4–5u., unequally 1-septate, constricted at septum, hyaline at first, becoming dark-brown with age; pseudoparaphyses filiform, numerous.

4. **Leprieurina radiata** sp. nov.

Spots none; fungus amphigenous, forming black, irregular crusts 5–20 mm. in diameter; pycnidia round, radial, 210–225u. in diameter, formed of light-brown cells about 12u. long and 3u. thick; ostiolum small, round, 10–12u. in diameter; mycelium dark-brown cob-webby, non-hyphopodiate, 6–8u. wide; coniodophores inconspicuous, 2–5u. long, hyaline; spores one-celled when young, hyaline, becoming two celled with age and with an olivaceous tint, oblong-elliptic, 9–16 × 3–5u. (Plate I fig. 2–3).

On leaves of *Chrysobalanus icaco* L., Loíza, P. R. Herbarium R. A. Toro *428* (Type).

The microscopical characteristics of this fungus is microthyriaceous and it is undoubtely a pycnidial form of one of the genera of this ascigerous group. The pycnidia are dimidiate and inverse-radiate like the perithecia of the Microthyriaceæ. They are solitary or in groups, posses an ostiolum but dehisce by desintegration of the walls. The mycelium is devoid of hyphopodia, like the mycelium of the ascigerous genus *Asterinella*, and forms a net of cross-webby threads by the anastomosing of the hyphæ. The spores arise from underneath the upper part of the pycnidia and very often, the small inconspicuous conidiophore remains attached (Plate I, fig. 3) so that it gives the spore the appearance of being ciliate. A character which makes this fungus very distinct from any other form thus far described is that the spores are oblong-elliptic instead of pyriform as is the case with the other species.

The systematic position of the genus *Leprieurina* is uncertain It has the same characteristics as *Asterostomella*, a fungus described by Spegazzini (Fungi Guaranitici 1: 157. 1883.) and originally placed by him among the Leptostromatacea of the Fungi Imperfecti. He indicated that *Asterostomella* is a pycnidial form of *Asterinæ*. There is no family among the Fungi Imperfecti that would accommodate the inverse-radiate, superficial pycnidial forms of the Microthyriacea. The abundance of superficial mycelium and the character of the pycnidium makes the group unlike any other of the Fungi Imperfecti. Arnaud (Les Asterinés 1: 204. 1918.), realizing this fact, proposes the family Microthyriopsidees for this group including the genus *Asterostomella* as type, and characterizing the genus as having colored-spores. *Leprieurina* Arnaud is also placed on this group, differing from *Asterostomella* in having 2-celled spores.

5. Perisporium Bromeliae Stevens.

Perisporium bromeliæ is described by Stevens (Trans. Illinois Acad. Sci. **10**: 168. 1917.) on leaves of *Bromelia Pinguin* L. This most interesting fungus was placed in this genus with some uncertainty as it shows relationship with different genera of the Perisporiaceæ and Sphaeriaceæ, although sufficiently distinct from either to constitute a new species. Stevens (l. c.) places the species under *Perisporium* Fr. since it agrees most closely with this genus although it differs in having 4-spored asci.

The writer compared the type-species of *Perisporium bromeliæ* Stev. (Stevens, Porto Rico Fungi No. *1329*) with a specimen of *Asteridium dimerosporioides* Speg. (C. Roumerguère Fungi selecti exsiccati No. *5211*) deposited in the herbarium of the New Botanical Garden and found them to be the same. This fungus, described by Spegazzini (Fung. Guar. **II**: 50. 1888.) on leaves of *Caraguata* sp., was transferred by Saccardo (Syll. Fung. **IX**: 434. 1891.) to *Zukalia dimerosporioides* (Speg.). Later, v. Höhnel (Frag. zur Myk. **157**: 617–618. 1917.) discussed fully the affinities and relationships of *Asteridium dimerosporioides* Speg. and placed it on the Hypocreales under the new combination *Gibberella dimerosporioides* (Speg.).

Recently, González Fragoso and Ciferri (Rev. Soc. Española Hist. Nat. **25**: 499 1925.) described and illustrated *Chaestosphaeria bromeliæ* sp. nov. on leaves of *Bromelia peregrina*. However, several collections of this same fungus, on *Bromelia Pinguin* L., were made in Santo Domingo by Kern and Toro. They were shown to Dr. Ciferri and he said the fungus is the same they had described as *Chaetosphaeria bromeliæ*. This fungus, on the other hand, was compared by the writer with *Perisporium bromeliæ* Stevens and found that they are the same. There is, nevertheless, some inconsistency in the statements regarding the number of spores in the ascus. González Fragoso and Ciferri say the ascus is 8-spored; Stevens says it is 4-spored. This same disagreement exists on the discussions of Spegazzini and v. Höhnel. Sydow and the writer have found that the asci are 4-spored instead of 8-spored. It is not surprising that the asci may appear as being 8-spored, since their walls are evanescent and when one ascus lies over the other and their walls desintegrate it gives the appearance as of being twice the actual number of spores. This same observation is made by v.

Hohnel and he says that "Spegazzini gibt die Asci vier-bis achtsporig an; doch wird dies ein Irrtum sein, da in 50 × 25u. grosen. Asci kaum acht 26–8u grossen Sporen Platz haben Ich fand die Asci stets viersporig, doch wenn zwei Asci ubereinander liegen, kann man sie leicht fur achtsporig halten "

The setæ observed on the perithecium by González Fragoso and Ciferri may be due to an error of vision The writer has always found that the mycelium consists of rather stiff, setæ-like, septate hyphæ growing more or less horizontally to the subtratum and occurring only at the furrows between the veins of the leaf; but never arising from the perithecium The perithecium is provided with a papilla and dehisces at maturity by desintegration of the cell-walls These characters are unlike any other hitherto described for a fungus of this group and are sufficient to justify the establishment of a new genus. Moreover, the type of the genus *Perisporium* Fr., *P. gramineum* Fr., is, according to Saccardo (Syll. Fung **I**: 56. 1882.), synonymous with *Crocicreas* Fr, one of the Excipuleae; the type of *Asteridium* Sacc., *A. pleurostyla* Sacc, is a *Meliola* according

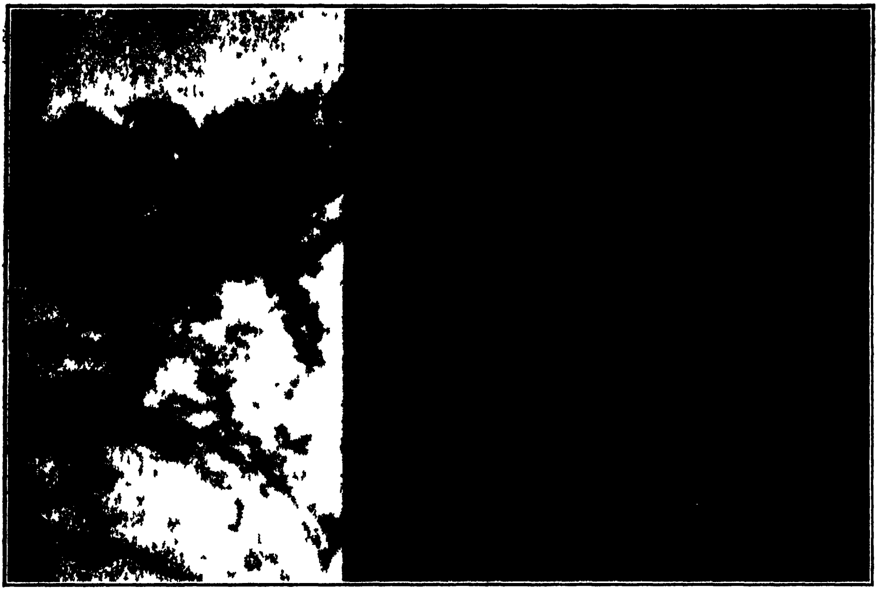


FIGURE 1 —Photomicrograph of a cross section of a leaf of *Bromelia Pinguin* L showing the position of the perithecia of *Toroa dimerosporioides* (A) Perithecia between the veins of the leaf Notice the setæ like mycelial hyphæ faintly shown on the left hand side of the first perithecium (B) Cross section of a perithecium 90

to Theisseen and Sydow (Ann. Myc. 15: 424. 1927.), while *Zukalia* Sacc. is synonymous with *Chætothyrium* Speg. (Theissen and Sydow l. c. 477.). From the standpoint of modern procedure in nomenclature the generic names *Perisporium* Fr., *Asteridium* Sacc. and *Zukalia* Sacc. has no standing whatever and must be abandoned. However, Spegazzini (Bol. Acad. Nac. Ci. Córdoba 26: 348. 1923.) claims that the name *Asteridium* Sacc. is to be retained since Saccardo when establishing the genus had in mind a dimidiate perithecium and not a cleistocarpus one as is the fruiting body of *Meliola* Fr. He, therefore, emends the characters of this genus, re-establishes the name and places it in the Dyctiopeltineæ of the Hemisphæriales. It is an undeniable fact that such procedure can not be accepted since it is impossible that Spegazzini could have been able to ascertain what Saccardo had in mind when he established the genus *Zukalia*, and moreover, such abstract-concept genera, supposing we accept this as one, are not altogether recommendable as they very often cause confusion. There is no doubt also that the fungus is not a *Gibberella* since its characters do not agree with what we understand as such.

Abundant material of *Perisporium bromeliæ* Stev. was collected in Porto Rico and sent to Dr. H. Sydow. After examination of this and some of Stevens' duplicates he decided that this fungus is a new genus and described it as follows:

Toroa Syd. gen. nov.

Myzel oberflächlich, fleckenförmige oder ausgebreitete schwärzliche Überzüge bildend, teils aus anliegenden meist stark gekrümmten, teils aus etwas abstehenden und ziemlich steifen Hyphen bestehend. Hyphopodien fehlen. Perithecien im Hyphenfilze des Myzels nistend, aussen, besonders unten, von demselben bekleidet, ziemlich klein, kuglig, völlig geschlossen, aber fast immer mit deutlicher flacher Scheitelpapille versehen, bei der Reife zerfallend. Membran brüchig-kohlig, mehrzellschichtig, fast opak schwarzbraun. Asci dickwandig, aber leicht zerfliessend, dick keulig, 4-sporig, sitzend. Sporen breit länglich-spindelförmig, ziemlich gross, mehrzellig, durchscheinend olivenbraun. Paraphysoiden sehr spärlich, undeutlich faserig-zellig. (Mycelium superficial, forming blackish crusts, hyphæ slightly bent or stiff; hyphopodia wanting; perithecia seated on the mycelium, spherical, nearly always provided with a papilla, dehiscing at maturity by desintegration of the cellwalls; membrane brittle-carbonaceous, composed of many layers of cells, black-brown; asci thick-walled, evanescent, ovate, sessile, 4-spored; spores oblong-spindleform, many-celled, translucent, olive-brown; paraphyses sparse, indistinct, filiform.)

Toroa differs from *Meliola* Fr. chiefly in its papillate perithecia and in the shape, color and septation of the spores.

Type species the following:

Toroa dimerosporioides (Speg.) Syd. comb. nov.

Asteridium dimesrosporioides Speg. Fungi Guaranitici **II**: 17. 1888.

Zukalia dimerosporioides (Speg.) Sacc., Syll. Fung. **IX**: 434. 1891.

Gibberella dimerosporioides (Speg.) v. Höhnel, Sitz K. Akad. Wiss. Wien **116**: 617-618. 1917.

Perisporium Bromeliae (Stev.) Trans. Illinois Acad. Sci. **10**: 168. 1917.

Chaetosphaeria bromeliae Frag. & Cif. Bol. R. Soc. Española Hist. Nat. **25**: 449. 1925.

Myzel oberflächlich, nur hypophyll, bald ziemlich kleine, ganz unregelmässig eckige ca. 1–1.5 cm. grosse, schwärzliche, ziemlich scharf begrenzte Flecken, bald mehr oder weniger weit ausgebreitete, oft grosse Teile des Blattes gleichmässig überziehende, grauschwärzliche, ziemlich lockere wollig filzige Überzüge bildend, aus dünnwandigen der Epidermis anliegenden durchscheinend olivenbraun gefärbten, ziemlich kurzgliedrigen, ca. 3–5u. dicken, meist stark und verschieden gekrümmten Hyphen bestehend, von welchen sich dünnwandige, durchscheinend schwarzbraune, ca 3–4u. dicke, bis über 600u. lange, mehr entfernt septierte, ziemlich steife, wirr durcheinanderlaufende, fast borstenartige Hyphen erheben, aber bald eine zur Oberfläche des Substrates mehr oder weniger horizontale Richtung einnehmen und ein in den Furchen zwischen der Nerven bis ca. 100u. hohes, ziemlich lockeres Geflecht bilden, in welchen die Perithecien nisten. Perithecien nur in den Furchen zwischen den Nerven in lockeren oder dichten parallelen Längsreihen wachsend, meist ziemlich regelmässig rundlich, ca. 80–130u. im Durchmesser, vollständig geschlossen, aber mit einer flachen, gestutzt kegelförmigen oft ziemlich undeutlichen Papille am Scheitel, bei der Reife meist ganz zerfallend. Peritheciummembran brüchig-kohlig, aus einigen Lagen von fast opak schwarzbraunen, mehr oder weniger zusammengepressten sehr unregelmässig eckigen, ziemlich dünnwandigen, etwa 4–7u., seltener

bis ca. 10u. grossen Zellen bestehend, aussen durch schwach vorspringende Zellen und kleine Zellkomplexe sehr feinkörnig rauh, besonders unten locker mit Hyphen des Myzelfilzes besetzt, innen rasch in eine dünne hyaline oder fast hyaline undeutlich konzentrisch faserige Schicht übergehend. Asci in geringer Zahl, dickkeulig oder länglich ellipsoidisch, am Scheitel etwas vorgezogen, mit stark verdickter Scheitelmembran, stumpf abgerundet, nach unten hin stark erweitert, dann plotzlich zusammengezogen, sitzend oder sehr undeutlich und kurz gestielt, dickwandig, aber leicht zerfliessend, 4-sporig. Sporen ziemlich breit länglich-spindelförmig, beindendig ziemlich stark und gleichmässig verjüngt, stumpf abgerundet, gerade oder schwach sichelförmig gekrümmt, mit 2 ungefähr im oberen und im unteren Viertel der ganzen Länge befindlichen Querwänden versehen, nicht oder nur sehr undeutlich eingeschnürt, mit ziemlich grobkörnigem Plasma oder mit 1–2 undeutlichen aber ziemlich grossen Oltropfen, die mittlere Zelle meist ca: 15-17u. lang tonnenförmig durchscheinend olivenbraun, die beiden Endzellen etwa 7–8u. lang stumpf konisch und meist deutlich heller gefärbt, im ganzen 25–36u. lang, 9–11u. dick, Paraphysoiden sehr spärlich, undeutlich, faserig zellig. (Mycelium superficial, bypophyllous, forming small, irregularly angled, black, definite spots about 1–1.5 cm in size, sometimes confluent to form larger spots: outer walls of the host epidermis stained brown; hyphæ thin-walled, translucent, black-brown, 3–4 thick, up to 600u. long, septate, somewhat stiff, bristle-like, more or less horizontal to the substratum and then about 100u high, always on the furrows between the veins of the leaf and with the perithecia seated on them; perithecia in loose or compact longitudinal rows, spherical, 80–130u. in diameter, astomous but with a conical papilla, dehiscing at maturity by desintegration of the cell-walls: membrane black-brown, cells thin-walled, 4–7u. large: asci few, ovate or elongate-ellipsoid, thick-walled at the upper portion, sessile or with a very short pedicel, evanescent, 4-spored: spores oblong-fusiform, straight or slightly curved, irregularly 2-septate, with 1 or 2 indistinct but some what large oil drops; 25–36 × 9–11u., translucent, olive-brown, the middle cell about 15-17u. long, barrel-shaped; end cells about 7–8u. long, obtuse-conic; paraphyses sparse, indistinct, filiform.

On leaves of *Bromelia Pinguin* L. Herbarium University of Illinois (Stevens) No. *1329*. Cornell University. Explorations of Porto Rico (Whetzel, Kern and Toro) No. *2536*. University of Porto Rico Explorations of Santo Domingo (Kern and Toro). No *194*, and *207*.

On *Caraguata* sp. (C. Romerguére Fungi selecti exsiccati No. *5244.*) South America.

6. Asterina Melastomacearum Ryan.

The fungus *Asterina Melastomacearum* sp. nov. is described by Ryan (Mycol. **16**: 186. 1924) on leaves of *Miconia racemosa* (Aubl.) DC. and *M. impetiolaris* (Sw.) D. Don., respectively. Two specimens of this fungus have been examined by the writer (Porto Rico Fungi (Stevens) Nos. *7037, 375*) and both agree with the description given by Arnaud (Les Asterinés **I**: 168. 1918) for *Astérina Melastomatis* Lév. The fact that this fungus is very common in other parts of the world on members of the *Melastomaceæ*, makes more certain the possibility that *Asterina Melastomacearum* Ryan is the same as *Asterina Melastomatis* Lév., in which case the former becomes a synonym of the latter for reason of priority (Plate I, figs. 8, 9 & 10).

EXPLANATION OF PLATE I

FIGURE 2—Diagramatic sketch of a leaf of *Chrysobalanus Icaco* showing the distribution of colonies of *Leprieurina radiata* × 1

FIGURE 3—Spores of *Leprieurina radiata* sp nov Notice the persistent sporophore on one of the spores × 800

FIGURE 4—Ascus and spores of *Microthyrium Psychotriae* (Ryan) comb nov × 800

FIGURE 5—Diagramatic sketch of a leaf of *Psychotriae* sp showing colonies of *Microthyrium Psychotriae* (Leaf × 5, colonies × 2)

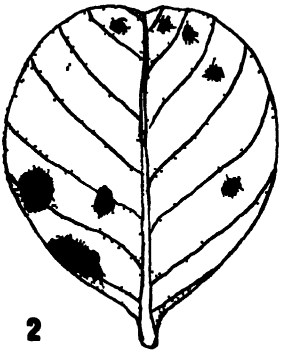
FIGURE 6—A perithecium of *Toroa dimerosporioides* (Speg) Syd showing method of dehiscing Also the setaclike character of the mycelium is shown × 95

FIGURE 7—Two spores of *Toroa dimerosporioides* × 800

FIGURE 8—Mycelium and hyphopodia of *Asterina Melastomatis* Lev × [illegible]

FIGURE 9—An ascus with spores of *Asterina Melastomatis* × 800

FIGURE 10—Two spores of *Asterina Melastomatis* × 800



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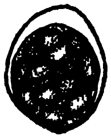

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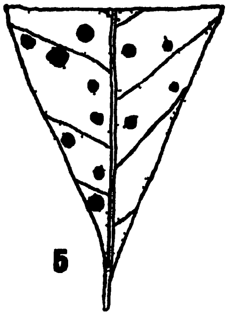

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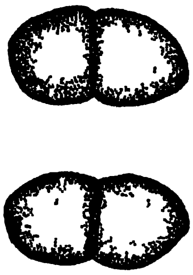

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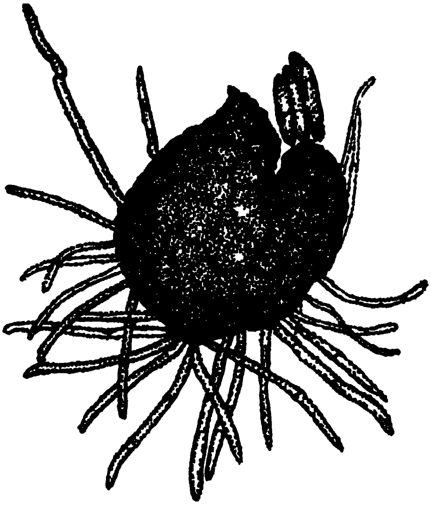

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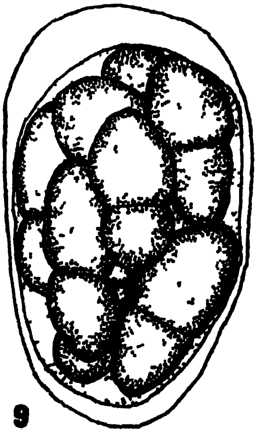

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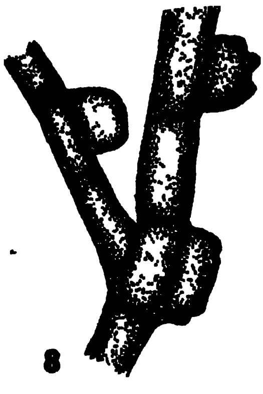

8

PLATE I

THE ANTHRACNOSES OF CITRUS FRUITS, MANGO AND AVOCADO

J. A. B. NOLLA

INTRODUCTION

The present paper presents a comparative study of the anthracnose diseases of the mango, avocado, and citrus fruits to determine the causal relations of *Colletotrichum gloeosporioides* Penz., *Gloeosporium limetticolum* Clausen and possibly other species of fungi to these diseases.

The diseases known as blossom blight, leaf spot, and fruit rot of the mango (*Mangifera indica* L.) have been reported to be caused by the fungus *Colletotrichum gloeosporioides* Penz. by Bessey **(1)**, Cardin **(3)**, Fawcett **(15)**, Mc Murran **(25)** and others **(7, 27, 38)**. Higgins **(19)** reports mango blight in Hawaii caused by a species of Colletotrichum However, Nowell **(26)** says that the fungus is usually known as *Gloeosporium mangiferæ* Henn., but that it has also been known as *Colletotrichum gloeosporioides* Penz. Again Cook **(10)** and Fawcett (1. c.) hold that blossom blight is caused by *Gloeosporium mangiferæ* and Stevens **(35)** reports the same fungus on mango leaves.

A similar disease is found on the avocado (*Persea Persea* L). A species of Colletotrichum has been found to cause black spot and has been isolated from the tissues of diseased fruits, stems and twigs. The identity of this fungus with *Colletotrichum gloeosporioides* has been maintained by different writers **(10, 26, 27 and 37)**.

The wither-tip, blossom blight, and fruit canker of the limes has been studied thoroughly along with the wither-tip, spotting of leaves and fruit, and streaking of the fruit of other citrus trees, *i. e.*, pomelo and orange. Hume **(20)** and Massee **(24)** give information concerning the anthracnose of the pomelo; Cook **(8)** reports *Colletotrichum gloeosporioides* as causing the anthracnose of citrus fruits including the lime. Duggar **(11)** and Rolfs **(29)** sustain the same view as Cook as to the host relations of the pathogenes, Clausen **(5)** finds that *Colletotrichum gloeosporioides* is not responsible for the wither-tip of the lime. He studied and described another organism, *Gloeosporium limetticolum*. It appears from his and later investigations by Fulton **(7)** that the true pathogene of the lime is *Gloeosporium limetticolum*, while *Colletotrichum gloeosporioides* is restricted to other hosts, especially citrus fruits other than lime, and further that it is not an active pathogene. Fawcet **(16)** separates the two pathogenes in like manner. Cook (1. c.) in 1906 advanced the statement that "the fungus which has been grown in pure cultures proceeding from these large spots on the leaves is not the same as that which we obtained from the withered leaves of the lime." Nowell (1. c.) believes that *C. gloeosporioides* is a weaker parasite than *G. limetticolum.* Furthermore, he dwells upon the fact that the former partakes mainly of the nature of a saprophyte. The same position has been taken by Thomas **(42)**.

In the opinion of the writer, *Colletotrichum gloeosporioides* Penz is the cause of the anthracnose of the mango, orange, pomelo, lemon, avocado and may be the cause of the wither-tip of limes.[1] Again we have found *Colletotrichum gloeosporioides* causing the lime wither-tip only in a few cases, while *Gloeosporium limetticolum* occurs more frequently especially in fruit spots. In this way we have verified Clausen's (1. c.) and Fulton's (1. c.) findings and conclusions that *Gloeosporium limetticolum* is an active pathogene of the lime. However, we differ from their views and also the views of Winston **(44)** as to the pathogenicity of *Colletotrichum gloeosporioides.* Quoting Fulton: "Winston, in connection with his studies of citrus tear stain, was unable to find, among numerous strains of *C. gloeosporioides* tested, any indication of active pathogenicity on very young fruits of various citrus species." We found during the past year a heavy shedding of the young fruit of lemon, orange, and pomelo. The cause for a considerable part of this shedding was found to be *C. gloeosporioides.* All strains from the hosts used in this investigation were obtained from such fallen small fruits. Thus, our position, in this question will be that *C. gloeosporioides* is, at least under Porto Rican conditions, an active pathogene.

A brief history and discussion of the diseases are given in this paper and cross-inoculation experiments and cultural characteristics are presented in detail.

PART I

HISTORY AND DESCRIPTION OF THESE DISEASES

Anthracnose of Citrus Trees other than Limes. (*Colletotrichum gloeosporioides* Penz.)

The causal fungus was first studied and described by Penzig in 1882. In 1904, Rolfs **(29)** described the disease from Florida. In

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[1] This opinion is based on the studies of Porto Rican material with reference to the published literature and not on the examination of the type material.

1909, it was reported from Porto Rico by Fawcett **(14)** and in the same year, by Essig **(13)** from Santa Paula, California. Other reports record the disease in Cuba, Australia, Italy, Malta, Jamaica, Mexico and Brazil.

The disease occurs as a fruit and leaf spot, fruit drop and as a wither-tip of twigs. The symptoms are like those of the lime anthracnose except for the fruit and leaf spot. Spots of leaves occur only on debilitated or weak parts of the tree and only on old leaves. Fruit spots are to be found when the fruit has been bruised or injured. The fungus will enter through wounds and in moist weather particularly will produce a rot which progresses rapidly into the core resulting in a blackening of the tissues and seeds. The spots grow to be 5–6 cm. in diameter. The color of the spots is at first fleshy but later changes to a mummy brown or a chestnut brown.

This fungus in Porto Rico was found to be the cause of a heavy drop of the young fruits of the orange, pomelo and Chinese dwarf lemon, when 1/4 to 1 or 1 1/4 inches in diameter. The drop occurred during the month of May and was especially destructive in the vicinity of the Station and in the Bayamón district. The conditions prevailing at the time were warm weather with heavy rains. The young fruit when gathered from the ground showed a distinct browning at the stem end. When cut longitudinally the inside was found to vary from a fleshy to brown color and this coloration marks the progress of the fungus outward to the blossom end. The fungus has been isolated from bits of the tissues of the inside of orange, lemon, and pomelo fruits exhibiting these symptoms. The fungus was also found on grapefruit flowers which had dropped to the ground and on the spurs from which the fruits had fallen.

Anthracnose of Limes.

Nowell **(26)** reports that an epidemic of the fungus *Gloeosporium limetticolum* occurred in Trinidad in the months of July and August, 1918. From that time the disease spread, resulting in a failure of the lime industry there. The disease also occurs in British Guiana and in 1919 Nowell found the fungus on material sent from there. He also gives account of the appearance of the disease in Dominica in 1922. Other reports show it to be present also in Cuba, Jamaica, Australia, Italy, Brazil, Malta and Mexico but it has not been found in California.

The fungus attacks tender foliage, blossoms and fruits. On young shoots the disease commences on the unopened whorl of leaves which soon die, and from there progresses down for 3.5 or more centimeters. In our inoculations on small seedlings we have observed a similar effect. Fruiting bodies of the fungus appear rapidly on the surface of dead twigs under favorable moisture conditions, thus furnishing a constant source of inoculum.

On the inflorescence the disease may be described as follows: On unopened buds small brown discolorations appear. These grow in all directions and ordinarily cause the falling of the buds before they open. On expanded flowers the characteristic discolorations occur on petals, stigmas and styles but are most common on the stigmas (see fig. 2). There is much shedding of young fruit and in badly infested trees it is very seldom that we find healthy fruit.

Fruits that survive the period of greatest danger of infection may be attacked later. Cook and Horne **(9)** stated that infection of sour lime did not take place after the fruits were well set and Clausen **(5)** supports the same view. We have covered flower clusters with paper bags before the opening of the flower buds and when the fruits were about one-half or three-fourths of an inch in diameter the bags were removed. The fruit which appeared healthy was thus exposed to inoculation. Later observations showed that more than 50 per cent of such fruits took the disease, the cankers being produced as under normal conditions except that they were smaller. In that case circular to oblong spots which vary in size from 1–3.5 cm. × 2 cm. appear on the surface. At first the spots are brownish but with increasing size and age they turn to a fleshy color and the skin of the fruit is ruptured or cracked in many places, producing the characteristic cankers. In some cases the cracking is so pronounced and rapid that it includes a part of the adjacent healthy tissues. This cracking may occur in two directions but ordinarily, in one. It is not uncommon to see the fruit split along its whole length or width. The writer has seen some cases in which the rupturing of the skin or rind has progressed in both directions along the same path; *i. e.*, a longitudinal rupture has turned to the side and worked its way transversely, or vice versa, making a circular split around the fruit. The vesicles of the fruit are exposed on rupturing of the rind and carpel membrane, and there always seems to occur an abnormal enlargement of the same. There is also a gumming exudation.

Mango Anthracnose.

The first report of a mango blight appears to have been made by Cobb. **(6a)** in 1894. The symptoms of the disease are spotting of the leaves and fruit and a blighting of the blossoms. The spots on the leaves range from 5–10 × 7–25 mm. Some of them extend from the margin, between the main veins, toward the midrib. In some instances two or three spots coalesce, forming irregular areas. It appears that the fungus starts growing on both sides and midway between the midrib and the margin of the blades. The spots increase in size and extend to the margin. The center of the spot is ochraceous-orange[1] at first, becoming cinnamon-rufous with age. This particular spotting has been found in only one instance. On the fruit the disease appears as very small brown spots. These spots enlarge very soon, especially under moist conditions. With the increase in size of the spots there is an intensification of their color to almost black and splitting or cracking of the rind and a sinking of the affected area included in the spots. The spots very often coalesce, forming large irregular areas which sometimes cover the entire rind of the fruit. The spots are commonly found at or around the stem end region. Streaking is seldom observed in Porto Rico. The damage done to the fruit is very great and this seems to be true in other places.

The blossom blight is particularly destructive in this Island. The fungus attacks open flowers and young flower buds and may result in the destruction of the panicles. Various writers have established a definite relation between weather conditions and the damages done by the disease on the blossoms Collins **(7)** from Porto Rico and Higgins **(19)** from Hawaii state that the heavy rainfall together with a continued cloudy, wet weather, are responsible for a small crop of poor quality mangoes. The same seems to be true in Guatemala and Mexico. In this connection, Nowell **(26)** says that with blossom blight "the loss may be small or may be great according to the conditions prevailing".

McMurran **(25)** says: "The production of good crops of mangoes in Florida and throughout tropical and subtropical zones generally is very definitely related to the weather conditions at blooming time. Large crops cannot be expected when the weather at this time is moist and showery. This may be due to some extent to imperfect pollination, but the trouble is chiefly caused in Florida by the anthracnose fungus (*Colletotrichum gloeosporioides*)." Our observations lead us to support that view.

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[1] Color characters throughout the paper are based on Ridway's "Color Standards and Nomenclature".

Avocado Anthracnose.

The first report of the disease seems to be from Cuba by Cook.[1] Korer **(30)** reports it from Trinidad in 1910. Later reports come from Porto Rico by Stevenson **(38)** in 1918, and from Florida by Stevens **(37)** in 1922. The disease appears as a blossom blight, fruit rot and a leaf spot. The effects and appearance of the disease on avocado blooms is similar to those of the blossom blight of the mango. Small black spots or specks appear on the small flowers and result in their dropping. Flowers may also have their growth retarded and the young fruits may shed later. Blossom blight seldom occurs in Porto Rico. The shedding of the blossoms is almost entirely due to imperfect pollination.

On the fruit the symptoms of this disease are as follows: Spots appear over the surface as small light-brown discolorations of the skin of the fruit. They enlarge very rapidly, the color at the same time changing to olive-brown or black. This color corresponds to older growth while the younger growth (one-day old) is marked by a very light-brown ring or outer progressing zone. The fungus penetrates into the flesh and may even extend to the seed, which remains unaffected. There is a marvelous rapidity of rotting which makes the fruit useless. Our experiments with ripe and unripe fruit indicate that the fungus grows very slowly until the fruit begins to ripen. Inoculated unripe fruit is apparently unaffected until it begins to ripen; it is then destroyed in a very few days. The writer has found that the rotting is very prevalent in the market on fruits from which the stem has been removed. The Porto Rican farmer is not careful in the picking of the fruit, which he does by shaking the tree. This method gives many chances for inoculation of the fruit through wounds.

The symptoms of the disease on Guatemala varieties grown in Porto Rico are as follows: Small brown spots appear over the surface of the fruit. These spots grow slowly on unripe fruit, but on ripe fruit they enlarge and become sunken and black; cracking of the skin may occur around the spots. If a fruit is opened, making the cut through a spot, the rotting will be seen to have progressed more deeply in the center of the spot than on the sides, thus resulting in a concave rotted region. The cracks which result from the invasion of the fungus hyphæ open the way for the entrance of saprophytes which greatly aid in a rapid destruction of the fruit.

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[1] Dr Mel T Cook has stated personally to the writer that he found the disease in Cuba during his stay at the Estación Central Agronómica in the years 1902–1904

PART II

CROSS-INOCULATION EXPERIMENTS, CULTURAL CHARACTERISTICS, AND MORPHOLOGY OF THE PATHOGENES

Cross-inoculation Experiments.

Inoculation experiments have been conducted by various workers on different anthracnose organisms. Stoneman after working with anthracnoses **(41)**, says that we must not depend too much upon results from cross-inoculations in the laboratory, since, under the conditions prevailing, the hosts act as culture media. Cobb **(6b)**, Laubert **(22)** and Shear and Wood **(31)** are of the opinion that anthracnose fungi adapt themselves to a wide range of conditions. This makes careful experimentation necessary in order to make sure of the relations existing between the hosts and the parasites. Toro **(43)** conducted detailed studies with *Gloeosporium musarum* Cke. & Mas. and arrived at a similar conclusion.

The writer has performed inoculation experiments with the various organisms on different hosts under laboratory and field conditions. The organisms were isolated from the different hosts and each was designated according to its host; *i. e.*, the anthracnose fungus from the orange was marked, thus, *O*; that from the pomelo, *P*; that from the avocado, *Av.*; from the mango, *M*; from the lime, *L*; and from the lemon, *Le*. As there were a number of cultures from each host, the culture number was given after the corresponding host. Thus *Le 1* was used to signify culture No. 1 from the lemon; *L 1* to mean culture No. 1 from the lime; *O 1*, culture No. 1 from the orange, etc. The source of all cultures is as follows: M 1–M 15; and M 22–M 30 from ripe mangoes (native and imported varieties) from various places on the Island; M 16–M 21, from blighted blossoms; P 1–P 7, young dropped pomelo fruits; P 8–P 10, pomelo flowers, O 1–O 10, young fallen orange fruits, Le 1–Le 5, young fallen lemon fruits (Chinese dwarf lemon); L 1, L 2, L 3, L 22, L 24–L 26, from lime fruit spots or cankers; L 4, L 5, L 19, L 21, from lime withered twigs; L 6, L 7, L 8 and L 14–L 18, from lime leaf spots; L 9–L 13, from lime thorn spots; and L 23, from lime withered twigs from inoculation with L 3.

Isolations were made from fruit spots and rots mainly, in the case of citrus hosts; however, isolations were also made from the withered tips of twigs, spotted leaves and blighted blossoms of citrus and from blighted mango blossoms as well.

In the fruit-inoculation experiments, all fruit were first washed in a 1: 1000 mercuric chloride solution and finally with sterile distilled water and then placed in moist chambers, which had been washed in the same solution. Needle-prick inoculations were practiced. All trials were made in triplicate. The results are given below:

Inoculations on Ripe Mangoes.—Inoculations with all cultures from mango, pomelo, orange, lemon and lime 1, 3, 9–12, and 23 produced large brown to black spots, characteristic of the disease on mango. All cultures from the lime except those given above produced slight discolorations of the tissue around the point of inoculation but these discolorations were not characteristic of the disease on mango.

Inoculations on Avocados. - Inoculation on ripe fruits with Av. 1; M 17, 18 and 20; P 1; O 1; and lime cultures Nos. 1, 3 and 23, produced mummy-brown discolorations of the skin and rotting of the fruit. The same cultures when green fruits were inoculated did not show any effects until the fruits began to ripen. Inoculations with lime cultures Nos. 2, 24, and 26 on both ripe and green fruits produced a slight discoloration around the point of inoculation.

Inoculations of Lime Twigs – These twigs were inoculated with spores from natural lesions and with spores from cultures. The inoculations were made from a spore dilution in water applied to the twigs with an atomizer or a camel's hair brush Some of the twigs were injured and others were left uninjured They were covered with manila bags A fine mist of sterilized water was sprayed into all the bags every day after 5 p. m. The inoculations were made with spores from acervuli on mango, avocado, pomelo and lime. Also with spores from cultures grown from acervuli on mango, avocado, and pomelo; also with spores from the acervuli on lime; spores from the lime cultures 1, 2, 3, 23 and 24. All the above inoculations on lime twigs produced wither-tip and leaf spot

Inoculations of Lime Fruits.– The lime fruits were inoculated with the same organisms and in the same manner as the lime twigs. The results in all cases were negative except in the case of fresh spores from the lime and those from culture L 2 and L 24 in which cases small, cankerous spots were produced.

Inoculation of Pomelo Seedlings.—These seedlings were inoculated in the same manner and with the same organisms as the preceding. In all cases a wither-tip and leaf spot were produced except when the fresh spores direct from the lime and those from cultures L 2 and L 24 were used; in which cases there was no reaction.

On Mango Twigs.—Needle-prick spore-spray inoculations were made on the unopened buds of a new growth, and during rainy weather which insured a rapid growth of the host. Spores were used from acervuli on avocado, mango, and pomelo, from cultures of L 1, L 3, L 23, and L 2, L 24 and L 26.

The effect of all inoculations except those with L 2, L 24, and L 26 was as follows: Rapid dying of the young twigs causing small leaves of the young buds to shed comparatively early. Ten days after inoculation, the dying of the twigs had progressed downward about 3 cm. Infection is first manifested by slight browning or darkening of the adjacent tissues, then the twigs turn black (see fig. 3). The results with L 2, L 24 and L 26 were negative.

On Avocado Twigs.--The same general plan of inoculation and with the same organisms was followed as with mango twigs. All inoculations showed negative results.

SUMMARY CONCERNING THE RESULTS OF INOCULATIONS ON POMELO SEEDLINGS, LIME TWIGS, LIME FRUITS, MANGO TWIGS, AVOCADO TWIGS, RIPE MANGOES, AND GREEN AND RIPE AVOCADOS

The results on these hosts tend to separate the cultures used in the foregoing inoculations into two groups: *Group I*, consisting of all cultures from the avocado, mango, pomelo, possibly orange and lime cultures Nos. 1, 3 and 23; *Group II*, consisting of cultures L 2, L 24 and L 26.

It was especially noticeable that cultures which produce the anthacnose of mango, avocado, orange, pomelo, and some producing wither-tip of the lime in nature, were not able to produce the lime fruit spot or canker. This peculiar characteristic makes the above separation into groups more important. It is also apparent that these anthrocnose-producing fungi have no effect on avocado twigs. Mango twigs when tender seem to be susceptible to the attack of *Colletotrichum gloeosporioides*. At least, this appears to be true under experimental conditions.

Cultural Characteristics.

The writer has made a careful study of the comparative behavior of the fungi under consideration on different media. A large variety of media have been carefully prepared and used in this work. All sugar media used were sterilized in the Arnold steam sterilizer; all other media in the autoclave at 20 pounds pressure for 30 minutes. Only 10 c.c. of the medium was put in each tube. All petri plates used were of the same size. All plates were poured the day previous to inoculation. Inoculations were made during the morning. They were made in triplicate for each culture and the tests were twice repeated. Growth was measured in centimeters in diameter at the end of seven days for solid media in petri plates. For liquid media growth was estimated by rapidity of growth and character of the substratum. Color changes were carefully noted and recorded. The results are given in the following pages. Tables and plates are here presented.

Rate of Colony Growth.

The growth of the colonies of each culture on 2 per cent nutrient glucose, 2 per cent nutrient saccharose, 2 per cent nutrient lactose, 2 per cent nutrient-dextrine, oat-meal, wheat-flour, and corn-meal agars was measured at the end of seven days and the results given as centimeters in diameter of colonies.

For convenience, all cultures from each host exhibiting a close relation in size in diameter of colony were grouped together. Table I includes the maximum, mean and minimum sizes of each group of colonies.

From an examination of Table I, it will be seen that there is a very sharp line of demarkation between Group 6, which includes cultures L 2, L 4–L 8, inclusive, L 14–L 22, inclusive, and L 24–L 26; and all other groups under which all mango, avocado, pomelo, lemon, and orange cultures with L 1, L 3, L 9–L 13, inclusive, and L 23 cultures. Thus, the means in all media for Group 6 run from 4.255 to 4.96 cm in diameter and minimum growth was 4 to 4.80 cm. with the maximum growth being 4.40 to 5.60 cm. in diameter; while measurements for the other groups taken as a whole are: mean, 6.28 to 8.04; minimum, 5.0 to 8.0, and maximum, 7.0 to 8.5 cm.

Therefore on the basis of colony size we will place tentatively, all cultures of Group 6, under one species and call it *Gloeosporium limetticolum* Clausen, including cultures L 2, L 4–L 8 inclusive, L 14–L 21, inclusive, L 22, L 24–L 26 inclusive, and also L 4–L 8 inclusive. This will constitute *Main Group I.* All other cultures (L 1, L 3, L 23, all mango cultures, all avocado, pomelo, orange and lemon cultures) under another species *Colletotrichum gloeosporioides* Penz. This will be *Main Group II.*

Growth characters (size of spores, zonation, color of both culture and substratum, character of mycelium, etc.) of all cultures have been carefully observed with special reference to color behavior, on

2 per cent glucose-nutrient agar, 2 per cent saccharose-nutrient agar, 2 per cent dextrine-nutrient agar, oat-meal agar, and corn-meal agar.

We have worked with carbohydrate media mainly since these afford a good working basis for the separation of strains and even species. Ravn **(28)** in studies on the genus *Helminthosporium* finds a relation between carbohydrate nutrient and blackness of the fungus. Stevens and Hall **(34)** have found good data on other fungi to support this view. Color phenomena in fungi have been studied and discussed in several papers by Smith **(32)**, Stewart and Hodgkiss **(40)** and Hedgecock **(18)**. Relation of carbohydrate nutriment to color has also been established by Stevens **(36)**. He found in his studies on *Helminthosporium* that the colony changes black in the region of the carbohydrate.

In our studies green or olive and brown discoloration of the substratum has been observed with a large number of cultures of the mango, avocado, orange, lemon, pomelo and a few of the lime cultures (*Colletotrichum gloeosporioides*). Most cultures from the lime pathogene (*Gloeosporium limetticolum* Clausen) show a light salmon-orange to apricot-orange or colors approximating these.

An attempt has been made to simplify the rendering of the results giving them in tabular form. All cultures which are alike in their effects on the media were grouped together in each particular medium. In this way differences between cultures are easily noted and the separation of the two species *C. gloeosporioides* Penz. and *G. limetticolum* Clausen is made possible without great difficulty. The results are given for the glucose and corn-meal agars, in Tables II and III. The results and observations on the other media are omitted for brevity.

Cultures which on one medium fall under a certain group may belong under another group for some other medium. The relation between cultures which belong under the same species is thus established.

It is striking that cultures of *C. gloeosporioides* from mango, avocado, orange, pomelo, lemon and lime (Nos. 1, 3, 9, 10, 11, 12, 13 and 23 cultures) differ so much in cultural characters from those of *G. limetticolum* Clausen (lime cultures Nos. 2, 4, 5, 6, 7, 8, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26). A similar difference has been previously pointed out in relation to colony size.

Color behavior, character of mycelium and character of substratum of all mango, pomelo, orange, lemon and a few lime cultures Nos.

1, 3, 9, 10, 11, 12, 13, 23) are more or less similar. The avocado group is different. Our studies with the avocado cultures have not been very extensive, and therefore we are leaving them under the species *Colletotrichum gloeosporioides* Penz. Lime cultures Nos. 2, 4, 5, 6, 7, 8, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25 and 26 maintain a close relationship in the different characters of growth and development. The most peculiar character is the scanty mycelium in most of them.

The size of the acervuli is almost constant for the cultures of each species. The number of acervuli varies with the different cultures with both *C. gloeosporioides* and *G. limetticolum*. The acervuli of the former species are larger than those of the latter.

On the basis of growth character discussed above we are holding Clausen's (5) division into two species to be correct. Of greatest importance are the following characters: *Colletotrichum gloeosporioides*: aerial mycelium white or dark, profuse, sometimes fluffy; of rapid development; acervuli numerous in most strains, large; substratum brown, green or olive or shades of these two latter colors. *Gloeosporium limetticolum*: mycelium scanty in most cultures, white; acervuli small, numerous in most strains; substratum light salmon-orange or apricot-orange.

Effect of Reaction.

All cultures were grown in bouillon of different acid and alkaline concentration, *i. e.*, +40, +45, —40, —45, Fuller's scale. The same general method as for solid media was followed; *i. e.*, triplicates of each culture on every medium. The tests were made twice.

Growth was recorded at the end of ten days and the rate or amount of growth given as + + +, + +, +, + —, and no growth. Much growth was expressed by + + +, fair growth by + +, some growth by +, and very little growth or slightly noticeable was expressed by + —. The results are presented in Table IV. The +45 concentration is deleterious to all cultures and —45 to all except the avocado cultures. The *G. limetticolum* cultures do not grow in any of the four concentrations, so it seems probable that they must cease development at lower concentrations. The *C. gloeosporioides* cultures from the mango produce a fair growth in the +40 concentration, and those from the pomelo, orange, lemon, avocado and lime (L 1, L 3, L 9–L 13 inclusive, and L 23) some growth. Here again we have been able to verify Clausen's conclusion that there are two different species.

Size of Spores.

To throw more light on the differential behavior of the different cultures as influenced by different nutrients, comparative measurements were made of spores from seven-day-old cultures in various media and from natural sources.

Five hundred spores from each culture on glucose agar were measured for their lengths and widths. The spore-length table is omitted as a matter of brevity.

A constant variation was found in length of spores of the different cultures while the margin of the width differences was very narrow. From our results it appears that spore size is not a very reliable basis for the determination of species. However, Toro **(43)** in his studies on banana anthracnose distinguishes eleven strains of *Gloeosporium musarum* Cke. & Massee on the basis of spore size. Burger **(2)** finds differences in strains of *Colletotrichum gloeosporioides* Penz. in regard to spore size. The same relation is established by La Rue and Barlett **(21)** with *Pestalozzia guepini* Desm., Stackman and Piemeisel **(33)** with *Puccinia graminis* Eriks. & Hern., Leach **(23)** with *Colletotrichum lindemuthianum* (Sacc. & Magn.), Brios and Cav. and Christensen **(4)** with *Helminthosporium sativum* (Pammel), King and Bakke.

Mean length of spores of cultures of *Colletotrichum gloeosporioides* and *Gloeosporium limetticolum* on glucose agar are shown in Table V

There is a range of 14.32 ± 0.023 to 22.51 ± 0.0798 microns. This means that with the former there is a wider range of mean length than with the latter and at the same time the shortest lengths are met with in *Gloeosporium limetticolum* cultures.

It was found that many cultures approached each other in mean length of spores, which made it possible to classify them into groups on the basis of mean spore length Table VI shows the classification.

It was also noted that there were many cultures with the same modal lengths so a classification was prepared on this basis. This classification is given in Table VII.

The range of variability of spore lengths of a large majority of the cultures, judging from the preceding tables, is not very great and a correlation between this character and that of cultural characteristics and host behavior has not been established.

Burger **(2)** in his investigations of variation within *Colletotrichum gloeosporioides* found that many strains had the same mode for their spore lengths. Our findings verify this conclusion and at the same time prove that variation also exists in the fungus *Gloeosporium limetticolum*. Cultures of *Colletotrichum gloeosporioides* maintain a similar relation toward cultures of *Gloeosporium limetticolum*. Thus, L 1 which falls under the *C. gloeosporioides* group has the same modal length as L 2 of the *G. limetticolum* group, as shown by Table VII. Likewise, L 23, L 9–L 13 inclusive, have the same mode as L 14–L 21; the former belonging to *C. gloeosporioides* and the latter to *G. limetticolum*. The same relation exists between the cultures of *C. gloeosporioides* from different hosts as that occurring among individual cultures from the same host.

Effect of Medium on Spore Length.

In the study of the effect of media on the cultures it was soon observed that variability exists according to the medium. Spore length measurements were made from four media by the general plan followed in the preceding chapters, and the mean lengths calculated (see Table VIII).

The greatest mean length seems to occur on the dextrin and glucose agars for most cultures The lowest mean lengths appeared on the saccharose and oat-meal agars. From these results it might appear that on starch media the spore length is shorter. However, we do not have enough evidence at hand to arrive at a definite conclusion.

Lengths of Spores in Nature.

Spores were measured from fruiting masses or acervuli on mango blossoms, mango fruits, avocado fruits, lime thorn spots, lime leaf spots and lime twigs (see Table IX).

The length of spores from mango blossom varies from 13.19 to 19.04 microns with a mean of 16.87 ± 0.036 microns. The range of variation of spores from the fruit is wider than that of those from blossoms and the mean length is greater. The spores from the avocado have a minimum length falling under the range of minimum lengths of spores from the lime. The upper range or maximum length of spores is greatest for the spores from the lime twigs and leaf spots.

The measurements of spores obtained from pustules on lime thorns show some similarity to those of the spores from the mango and the avocado. This is further evidence that spotting on lime thorns is frequently caused by the fungus (*C. gloeosporioides*) causing the anthracnose diseases of those fruits. Our previous experiments and observations with cultures L 9–L 13 inclusive, obtained from lime thorn spots, show similar results.

Variation of Spore Widths.

The range of variability in width of spores was not so great as that for the lengths. See Table X. There is a constant, although not great variation in the mean width of the various cultures. However, the minimum and maximum widths are common for a large number of cultures.

MORPHOLOGY

Occurrence of setae.

Setæ have been but rarely found under natural conditions. They were observed on blighted mango blossoms kept in a moist chamber and on citrus leaves, but not on lime fruits. Most cultures of *C. gloeosporioides* produced setæ in carbohydrate media while no setæ were ever produced by cultures of *Gloeosporium limetticolum* under similar conditions.

Rolfs **(29)** reports setæ of *C. gloeosporioides* on oranges but says that they are frequently absent on tender lime twigs, and on "lime fruits usually absent". Clausen **(5)** uses the absence of setæ in the pathogen to distinguish lime wither tip from that of other citrus fruits. Nowell **(26)** takes a similar position. Our observations prove that the absence or presence of setæ will vary with the environment, and while not attaching much reliability to this characteristic, we are inclined to support Clausen's **(5)** conclusion. Stoneman **(41)**, Edgerton **(21)** and Shear and Wood **(31)** hold "That the setæ are variable as to presence or absence and that they are not reliable morphological characters to use in separating genera."

Conidiophores and Conidia.

All cultures of *G. limetticolum* develop conidiophores which are light or almost hyaline, those of cultures of *C. gloeosporioides* are slightly darker. Conidiophores from the avocado cultures of *C. gloeosporioides* seem to differ somewhat from those of the other cultures in shape and slightly in size and color. They are as a rule very light in color and broad at the middle with constrictions on both sides of the broad portion frequently occurring, and with pointed ends or even bases. They may be smaller than the conidiophores of the other cultures (see figs. 19, 20 and 21).

Clausen **(5)** uses the shape of spores as a strong point in distinguishing *G. limetticolum* fram *C. gloeosporioides*. He describes the spores of the two species as follows:

> "The conidia of the common wither-tip fungus have a peculiar very characteristic form. Typically one end is rather rounded, the other end is blunt, but

more or less obliquely truncate, and there is slight constriction at the middle of the spore. The conidia of the pathogenic fungus have one or both ends more or less pointed with very little tendency toward constriction at the middle.''

We have not found such differences existing between them on either spores from the natural source or those from cultures. The blunt end of the spores is just as true of *C. gloeosporioides* as of *G. limetticolum* (see figs. 8 and 9), and cases of the two ends being pointed have been found in both species (see figs. 12 and 13). Constriction of the spores although not frequent, occurs with both species (see figs. 10 and 11).

Vacuoles are more numerous and larger in the case of *G. limetticolum*, especially is this true of spores from cultures (see figs. 14 and 16). The medium seems to have an important relation on spore shape and form. All forms have been noted with both *C. gloeosporioides* and *G. limetticolum* in different media. Some are constricted at various places, others are very long and thin, while others are short and wide. Still others are very wide at one end and very narrow at the other, being more or less flask-shaped (see figs. 17 and 18).

The character of conidia still remains a rather doubtful or confusing basis in the distinction between *Colletotrichum gloeosporioides* and *Gloeosporium limetticolum*.

SUMMARY AND CONCLUSIONS

(1) *Colletotrichum gloeosporioides* Penz appears to be the cause of the anthracnose diseases of mango, orange, grapefruit, lemon, avocado, and sometimes of lime.

(2) Lime wither-tip may be caused by either *C. gloeosporioides* or *Gloeosporium limetticolum* Clausen.

(3) *Colletotrichum gloeosporioides* Penz. frequently causes spotting of lime blossoms and the wither-tip. It is also the cause of the spots on lime thorns. The latter is demonstrated by cultures L 9–L 13, inclusive, which behaved like other *C. gloeosporioides* cultures and very distinct from cultures of *G. limetticolum*.

(4) *Gloeosporium limetticolum* Clausen is the cause of wither-tip and leaf spot of limes.

(5) *G. limetticolum* appears to be the only cause of fruit canker or fruit spot of limes.

(6) Under artificial conditions the various cultures of *C. gloeosporioides* and *G. limetticolum* exhibit distinct cultural characteristics.

(7) Cultures from the avocado differ somewhat from cultures obtained from other hosts in cultural characteristics. The difference may not furnish enough evidence for their separation into a new species.

(8) There are such differences between most cultures from the lime and all cultures from the other hosts that Clausen's **(5)** separation of the former into a distinct species appears to be justified.

(9) The four most salient growth characters in which cultures of *C. gloeosporioides* varied from cultures of *G. limetticolum* or such cultures among themselves are: (*a*) size, number, and arrangement of acervuli; (*b*) color of acervuli and substratum; (*c*) character of aerial mycelium; (*d*) size of colonies.

(10) *C. gloeosporioides* can resist slightly more acid or alkaline concentrations than *G. limetticolum*.

(11) Setæ are occasionally present in *C. gloeosporioides* and absent in *G. limetticolum*.

(12) Variation in spore size is induced by the culture medium.

(13) There is great morphological similarity between *G limetticolum* and *C. gloeosporioides*.

(14) Environment induces variation in form and shape of spores.

(15) The character of conidia appears to be rather uncertain for distinguishing between *Gloeosporium limetticolum* and *Colletotrichum gloeosporioides*.

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TABLE I

Separation of Cultures of *C gloeosporioides* and *G. limetticolum* on the Basis of Colony Size in Centimeters in Diameter, at the end of seven days

Cultures in Each Group	2% Glucose agar			2% Saccarose agar			2% Dextrine agar			2% Lactose agar			Wheatmeal agar			Cornmeal agar			Oatmeal agar		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum
I- M 1 - M 30	6.0	7.08	8.0	6.7	7.61	8.2	5.5	7.12	8.0	6.0	7.53	8.2	5.9	7.43	7.9	6.1	7.19	7.6	5.8	7.24	8.0
II- P 1 - P 10 ..	6.0	6.89	8.0	6.8	7.24	7.8	5.8	6.90	7.8	5.0	7.18	8.0	7.0	7.60	7.8	7.0	7.74	8.0	7.0	7.36	7.7
III- O 1 - O 5	7.0	7.32	7.6	7.0	7.40	7.6	7.0	7.84	8.5	7.0	7.20	7.5	6.5	7.32	7.8	7.8	7.90	8.0	6.0	6.28	7.0
IV- Le 1 - Le 5 .	7.8	7.98	8.1	8.0	8.02	8.1	7.7	7.92	8.1	7.8	8.04	8.2	7.5	7.74	7.8	7.8	8.00	8.2	7.8	7.80	7.8
V- L 1, L 3, L 9, L 13 y L 23	7.3	7.75	8.0	8.0	8.10	8.3	7.1	7.75	8.0	7.4	7.90	8.1	7.7	7.86	8.0	7.8	7.95	8.0	5.2	7.63	8.0
VI- L 2 L 4, L 8, L 14 L 22, L 24 y L 26	4.0	4.71	5.0	4.1	4.87	5.1	4.1	4.25	4.4	4.0	4.49	5.1	4.2	4.85	5.0	4.8	4.96	5.1	4.1	4.68	5.6
VII- Av 1 - Av 6 .	7.7	7.75	7.8	7.8	7.98	8.2	7.5	7.60	7.7	7.0	7.13	7.3	7.3	7.36	7.5	7.4	7.47	7.5	7.6	7.73	7.8

TABLE II

Characters of Growth of All Cultures on 2 Per Cent Nutrient Glucose Agar. The cultures arranged into groups according to character of growth.

GROUP I M 1, M 2, M 3, M 4, M 5, M 6, M 20, M 21, M 16, M 17.	Acervuli large, numerous, in zones; *brick-red* in color; substratum: zones of *dark greenish-olive* with some *brick-red* marks underlying the masses of acervuli; older growth underlaid by *mars brown* color; mycelium profuse in long threads; *white* in some colonies; *grayish* or *dark* in others.
GROUP II M 7–M 15, M 22–M 27.	Acervuli large, numerous, zoned or not, all shades of color from *yellowish olive* to *olive* or *dark-greenish*-olive. Brown spots underlie some of the acervuli masses. Aerial mycelium profuse, dull white to dark in color In some colonies the acervuli are *salmon* in color with *brownish olive* or mummy brown substratum.
GROUP III P 2, P 3, P 4, P 6, P 7, P 9, P 10.	Acervuli large, numerous, zoned or not, all shades of color from *light ochraceous-buff* with *olive* markings to *ochraceous-buff* with substratum underneath the acervuli of a *cinnamon-rufous* color and *brownish-olive* in the inner zones. The medium under the old growth changes in some colonies to almost *dark brown* or *black* Mycelium profuse, *whitish*
GROUP IV P 1, P 8, P 5, O 1, O 3–O 5, Av. 6.	Acervuli large, numerous, zoned, *pale ochraceous salmon*. Color of substratum underneath the acervuli is *ferruginous*. Concentric ferruginous markings on colony. Aerial mycelium profuse
GROUP V O 2, LE 1–Le 5.	Acervuli large, numerous, zoned or not, *ochraceous-salmon;* substratum shows ochraceous salmon discoloration and much cinnamon brown or even ochraceous buff with cinnamon-brown. Mycelium profuse, O 2 more profuse than the others
GROUP VI L 5–L 8, L 22, L 24, L 25, L 4, L 2	Acervuli small, numerous or few, not zoned, *light-salmon* orange, mycelium in form of very short whitish threads.
GROUP VII L 14–L 21,	Acervuli small, numerous, not zoned, substratum unchanged, *profuse*, dull white.
GROUP VIII L 3, L 23, L 1, L 9–L 13.	Acervuli large, numerous, more or less zoned, flesh color. Substratum: *ferruginous* to *Kaiser-brown* with *brownish olive* zones or flesh-ocher. Aerial mycelium profuse whitish dull.
GROUP IX Av. 1 Av. 6.	Acervuli large numerous in old colonies, in young colonies only in central portion, *rufous*. Masses of spores borne on the aerial mycelium around the center of the colony are *grenadine pink* to *light salmon-orange*. Acervuli zoned or not. Mycelium white (snow); profuse, *floccose*, the long tufts radially arranged. The power for mycelial growth is remarkable, the tufts reaching the top dish and spreading under it.
GROUP X M 18–19	Acervuli large, numerous, perfect zonation, *apricot-orange* in color. Nearly always have central portion of colony of a gray mycelium. Tufts of gray mycelium also occur throughout the young growth.
GROUP XI L 26.	Acervuli small; numerous, *apricot orange* in color; central portion of colony is *bluish-black*.

TABLE III

Growth Characters of All Cultures on Corn-Meal Agar. They are arranged according to these characters.

GROUP I M 7–M 11, L 13, L. 1.	Acervuli large, numerous, zonation not distinct, salmon; substratum: *dark grayish-olive;* mycelium white, dark or gray, profuse.
GROUP II M 10.	Acervuli large, numerous, *rufous* or *apricot-orange.* Substratum: rufous or apricot-orange along the edge of colony *dark grayish-olive;* mycelium fair, dark.
GROUP III P 1–P 4.	Acervuli large, numerous, ferruginous; substratum *greenish-olive;* mycelium moderate, white or dark.
GROUP IV P 5–P 10, O 1.	Acervuli large, numerous, *light salmon orange* or *flesh-ocher;* mycelium scanty in some cultures, profuse in others.
GROUP V Lo 1–Lo 5.	Acervuli large, numerous, more or less zoned, *ochraceous salmon;* substratum: *ochraceous-salmon;* mycelium moderate to profuse, white (dull).
GROUP VI L 5–L 8.	Acervuli small, numerous, *not zoned,* flesh-ocher; substratum: *ocher-red,* aerial mycelium occurring as short threads, white.
GROUP VII L 9–L 12, L 22, L 24.	Acervuli large, numerous, slightly zoned, *flesh ocher;* substratum *flesh ocher,* green under acervuli, aerial mycelium occurring as long threads.
GROUP VIII L 3, L 23.	Acervuli large, numerous, not zoned; *rufous,* in streaks over surface of colony. Substratum: rufous; mycelium little, white.
GROUP IX L 14 L 21.	Acervuli small, numerous, *no zonation, flesh ocher,* substratum: *flesh ocher* to *ocher-red.* Small masses of mycelium, white.
GROUP X Av. 1–Av. 5.	Acervuli large, few, apricot orange, for the most part in a large mass in the center of the colony, otherwise scattered in small numbers throughout the surface or in zones; substratum: surface line *dark greenish olive,* more pronounced in some cultures than in others; mycelium either in the form of a large, white mass around the center of the colony or white, floccose, sometimes fluffy.
GROUP XI L 25, L 26.	Acervuli small, numerous, not zoned, flesh ocher, except a central green portion; substratum: *bluish* central portion, ocher-red outside it; aerial mycelium in form of very short threads.

TABLE IV

Shows Effect of Reaction. Growth on Bouillon of Different Acid and Alkaline Reaction

Culture	+ 40 Fuller's Scale	+ 45 Fuller's Scale	40 Fuller's Scale	—45 Fuller's Scale
M 1–M 30	+ +	No growth	+	No growth
P 1–P 10		No growth	+	No growth
O 1–O 5	+	No growth	+ Salmon acervuli on the surface	No growth
Ic 1–Ic 5	+	No growth	+	No growth
L 1, L 3, L 9, L 13, L 23	+	No growth		No growth
L 2, L 4, L 8, L 11, L 22, L 14, L 26	No growth	No growth	No growth	No growth
Av 1–Av 6	+	No growth	+ Large numerous submerged colonies	

TABLE V

Shows Mean Lengths in Microns of Spores of Cultures of *C. gloeosporioides* and *G. limetticolum* on 2 per cent Glucose Agar

Culture No	Mean	Culture No	Mean
M 1	14.85 ± 0.066	O 2	15.17 ± 0.041
M 2	15.57 ± 0.055	O 3	15.30 ± 0.072
M 3	15.55 ± 0.045	O 4	15.18 ± 0.075
M 4	16.23 ± 0.057	O 5	15.26 ± 0.087
M 5	16.06 ± 0.052	Le 1	14.97 ± 0.042
M 6	16.08 ± 0.080	Le 2	14.95 ± 0.056
M 7	19.25 ± 0.085	Le 3	14.55 ± 0.034
M 8	17.28 ± 0.095	Le 4	14.60 ± 0.047
M 9	16.70 ± 0.085	Le 5	14.32 ± 0.023
M 10	16.09 ± 0.067	L 1	14.55 ± 0.121
M 11	22.51 ± 0.078	L 2	14.36 ± 0.065
M 12	17.37 ± 0.064	L 3	15.25 ± 0.096
M 13	17.33 ± 0.075	L 4	15.85 ± 0.036
M 14	17.44 ± 0.061	L 5	15.63 ± 0.052
M 15	17.05 ± 0.066	L 6	15.89 ± 0.076
M 16	15.35 ± 0.080	L 7	15.84 ± 0.026
M 17	15.06 ± 0.040	L 8	15.35 ± 0.039
M 18	14.89 ± 0.047	L 9	16.18 ± 0.071
M 19	16.59 ± 0.069	L 10	16.12 ± 0.092
M 20	17.77 ± 0.066	L 11	15.13 ± 0.052
M 21	17.62 ± 0.061	L 12	14.86 ± 0.046
M 22	17.19 ± 0.036	L 13	15.23 ± 0.074
M 23	17.07 ± 0.075	L 14	15.92 ± 0.020
M 24	16.69 ± 0.065	L 15	15.29 ± 0.013
M 25	17.38 ± 0.053	L 16	15.08 ± 0.071
M 26	17.77 ± 0.050	L 17	15.71 ± 0.061
M 27	16.46 ± 0.059	L 18	15.[illegible] ± 0.028
M 28	15.27 ± 0.098	L 19	16.41 ± 0.052
M 29	15.50 ± 0.067	L 20	16.74 ± 0.029
M 30	15.81 ± 0.032	L 21	16.86 ± 0.096
P 1	16.09 ± 0.054	L 22	14.99 ± 0.015
P 2	18.05 ± 0.050	L 23	15.00 ± 0.039
P 3	14.88 ± 0.028	L 24	15.30 ± 0.016
P 4	15.37 ± 0.030	L 25	14.02 ± 0.033
P 5	16.08 ± 0.046	L 26	14.17 ± 0.098
P 6	16.12 ± 0.037	Av 1	16.89 ± 0.082
P 7	16.35 ± 0.095	Av 2	17.33 ± 0.063
P 8	16.28 ± 0.045	Av 3	17.73 ± 0.085
P 9	19.34 ± 0.062	Av 4	17.94 ± 0.031
P 10	17.26 ± 0.051	Av 5	16.64 ± 0.088
O 1	16.03 ± 0.047	Av 6	16.57 ± 0.088

TABLE VI

Separation of Cultures of *C. gloeosporioides* and *G. limetticolum* into Groups According to Mean Lengths of Spores in Microns

Group	Cultures	Range mean length in microns
I	M 1—M 3, M 16—M 18, P 3, P 4, O 2 -O 5, L 1 -L 3, L 5, L 8, L 11—L 13, L 15—L 17, L 22—L 24	14.85 —15.816
II	M 4—M 6, M 9, M 10, M 19, M 24, M 27, P 1, P 5—P 8, O 1, L 4, L 6, L 7, L 9, L 10, L 19 -L 21	15.839 16.861
III	M 8, M 12—M 15, M 20—M 23, M 25, M 26, P 10, Av 1 -Av 3	16.890 -17.794
IV	Av 4, P 2	17.91 - 18.90
V	M 7, P 9	19.257—20.250
VI	M 11	21.50 —22.511

TABLE VII

Classification of Cultures into Groups According to Modal Spore Length

Culture number measuring (in microns)								
11 70	18 10	18 90	14 60	16 10	16 80	17 50	19 00	20 50
L 24	M 16 M 17 M 18 Ic 4 Ic 5 I 4 I 5 I 6 I 7 I 8 I 22 I 25 I 26	M 19 I 1 I 2	M 12 M 13 M 14 M 1 P 1 P 3 P 4 P 5 P 6 P 7 P 9 O 1 O 2 O 3 O 4 O 5 Ic 1 Ic 2 Ic 3 I 9 I 10 I 11 I 12 I 14 I 15 I 16 I 17 I 18 I 19 I 20 I 21 I 23 Av 6	M 2 M 3 M 4 M 5 M 6 M 8 M 9 M 10 M 22 M 23 M 24 M 25 M 26 M 27 M 28 M 29 M 30 I 2 P 8 P 10 I 3 I 13 Av 1 Av 2 Av 8 Av 4	M 20 M 21	M 26 Av 5	M 1	M 7 M 11

TABLE VIII

Shows Effect on Medium on Spore Mean Length (in Microns)

Strain No	2 Glucose agar	2% Saccharose agar	2% Dextrine agar	Oatmeal agar
M 7	19 25 + 0 085	16 08 ± 0 047	16 92 + 0 027	16 51 ± 0 031
M 8	17 28 + 0 095	16 23 + 0 050	18 03 + 0 024	15 50 0 048
M 9	16 70 + 0 085	18 31 0 063	19 49 + 0 060	15 32 ± 0 072
M 12	17 37 + 0 064	16 61 ± 0 071	16 62 ± 0 053	18 05 0 056
M 15	17 05 ± 0 066	15 95 + 0 043	18 05 ± 0 014	16 72 ± 0 065
O 1	16 03 + 0 047	15 17 + 0 030	15 80 ± 0 027	14 25 ± 0 071
O 2	15 17 ± 0 041	16 6 ± 0 022	14 90 ± 0 036	14 48 ± 0 020
P 5	16 08 ± 0 046	18 98 + 0 046	15 08 ± 0 049	14 24 ± 0 079
P 7	16 85 ± 0 095	14 82 ± 0 021	15 08 ± 0 052	14 27 ± 0 028
L 1	14 55 ± 0 121	16 51 ± 0 057	16 72 ± 0 020	16 07 ± 0.037
L 8	15 25 ± 0 096	14 33 ± 0 089	15 88 ± 0 049	13 66 ± 0 042
L 5	15 63 ± 0 052	16 21 ± 0 084	18 03 ± 0 031	16 89 ± 0 064

TABLE IX

Length Measurements in Microns of Fresh Spores of *C. gloeosporioides* and *G. limetticolum*

Source of Fresh Spores	Maximum	Mean	Minimum
Mango blossom blight	19.04	16.87 ± 0.086	13.19
Mango fruit spots	22.00	16.12 ± 0.049	11.78
Mango fruit spots	23.45	17.50 ± 0.029	13.19
Avocado rot	20.50	19.04 ± 0.032	11.78
Lime thorn spots	16.12	14.66 ± 0.021	11.78
Lime leaf spots	43.98	14.60 ± 0.099	11.78
Lime withered twig	24.92	18.29 ± 0.066	13.19
Lime withered twig	26.39	14.66 ± 0.035	10.26
Lime withered twig	23.45	16.12 ± 0.085	10.26

TABLE X

Maximum, Mean and Minimum Widths in Microns of Cultures of *C. gloeosporioides* and *G. limetticolum*

Culture	Maximum	Mean	Minimum
M 12	5.42	4.40 ± 0.017	3.22
M 17	5.57	4.61 ± 0.081	3.66
M 18	5.72	4.43 ± 0.062	4.10
M 20	5.72	4.62 ± 0.089	4.10
M 22	5.57	4.69 ± 0.027	4.10
M 26	5.42	4.43 ± 0.069	3.66
M 27	5.42	4.37 ± 0.078	3.22
M 29	5.42	4.15 ± 0.088	2.98
P 1	5.42	5.18 ± 0.080	3.66
P 2	5.42	4.54 ± 0.090	3.51
P 4	5.42	4.41 ± 0.066	4.10
P 5	5.57	5.16 ± 0.031	4.40
P 6	5.42	4.69 ± 0.039	3.22
P 7	5.57	4.25 ± 0.045	2.98
P 8	5.57	4.40 ± 0.086	4.10
P 9	5.57	4.18 ± 0.035	3.66
P 10	5.72	5.24 ± 0.086	4.10
O 1	5.57	4.66 ± 0.049	4.10
O 2	5.42	5.18 ± 0.023	3.22
O 4	5.57	4.38 ± 0.041	3.22
Le 1	6.16	4.47 ± 0.087	4.10
Le 3	5.18	4.46 ± 0.075	3.66
Le 4	5.42	4.58 ± 0.032	4.10
Le 5	5.42	4.54 ± 0.035	4.10
L 22	5.42	4.29 ± 0.044	2.98
L 2	5.57	4.46 ± 0.087	3.22
L 23	5.57	4.55 ± 0.086	3.51
L 24	7.33	4.98 ± 0.027	3.66
L 25	6.16	4.92 ± 0.018	3.66

PLATES I–VI

LEGEND FOR PLATE I

FIGURE 1.—Mango leaf showing spots caused by *Colletotrichum gloeosporioides.*

FIGURE 2.—Blight of lime blossoms produced by *Gloeosporium limetticolum.* (A) Lesions on the petals. Young fruits (B) with diseased stigmas shown in black (1, 2); normal young fruit (3)

FIGURE 3.—Withered twigs of the mango caused by inoculations with *C. gloeosporioides* *a,* Mango cultures; *b,* Avocado cultures; *c,* Pomelo cultures; *d,* Orange cultures.

FIGURE 4.—Setæ of *C gloeosporioides* on *a,* Oat-meal agar; *b,* Nutrient agar; *c,* Cook's No 11 agar; *d,* Avocado cultures on Cook's No. 11 agar.

FIGURE 5.—Cross-section of a pustule of *C. gloeosporioides* on lime stigma Shows conidiophores, conidia and setæ

FIGURE 6.—Cross-section of pustule of *C. gloeosporioides* on the lime

FIGURE 7.—Wither-tip of the lime caused by *G limetticolum*

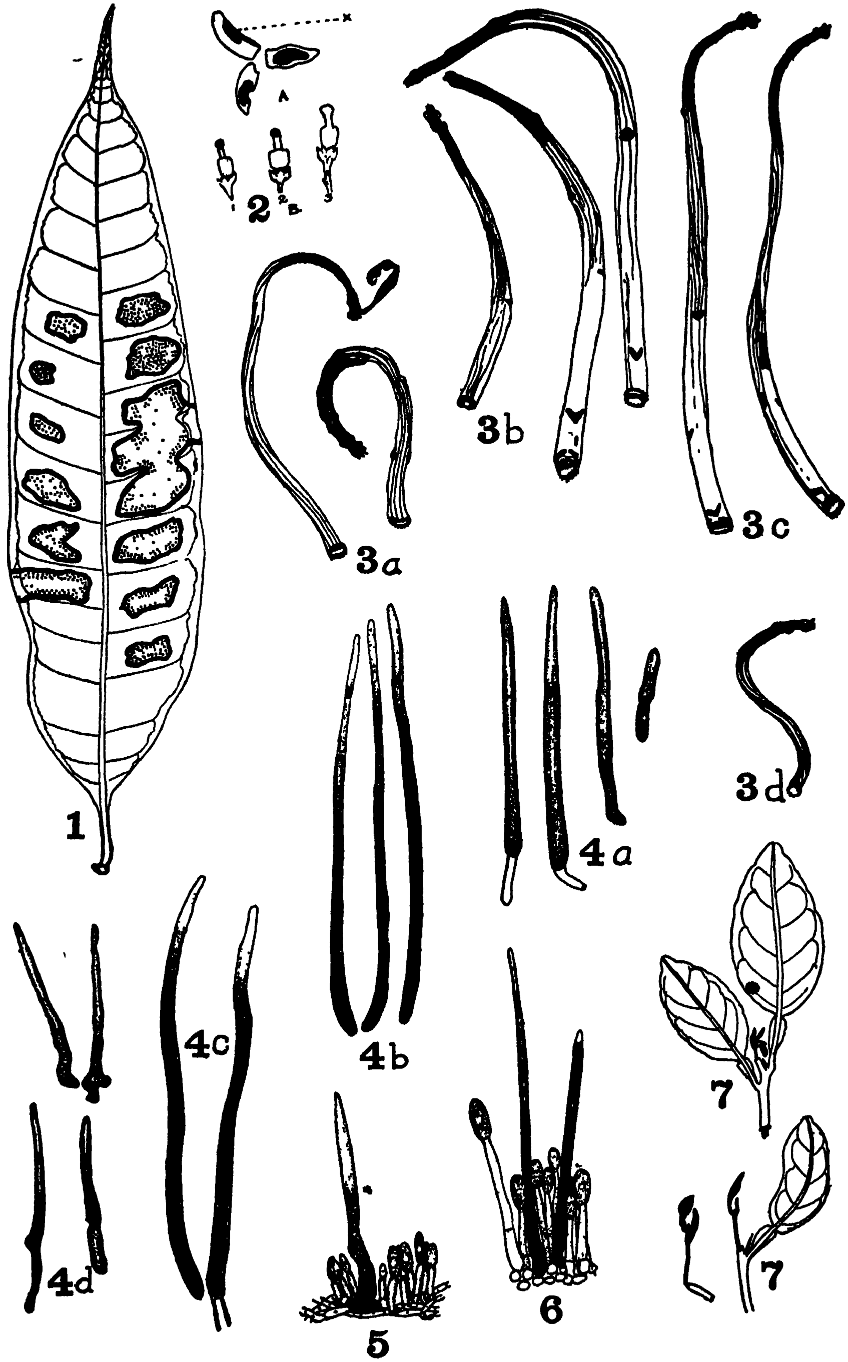


PLATE I

LEGEND FOR PLATE II

FIGURE 8.—Spores of *G. limetticolum* showing blunt ends.

FIGURE 9.—Spores of *C. gloeosporioides* showing blunt ends

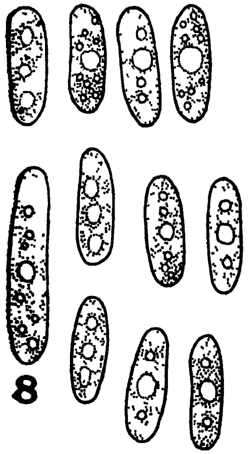
FIGURE 10.—Spores of *G. limetticolum* showing constriction

FIGURE 11.—Spores of *C. gloeosporioides* showing constriction.

FIGURE 12.—Spores of *G. limetticolum* showing ends more or less pointed.

FIGURE 13.—Spores of *C. gloeosporioides* showing ends more or less pointed.

FIGURE 14.—Shows character of the plasma of spores of *G. limetticolum*.



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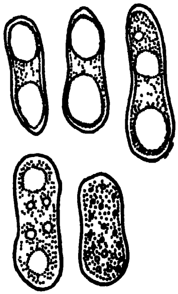

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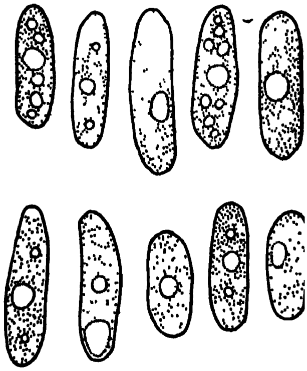

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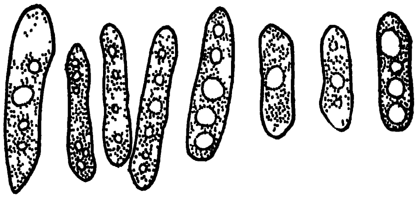

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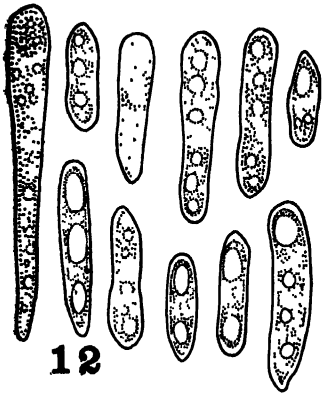

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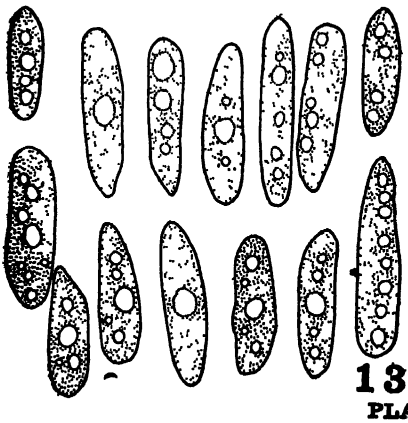

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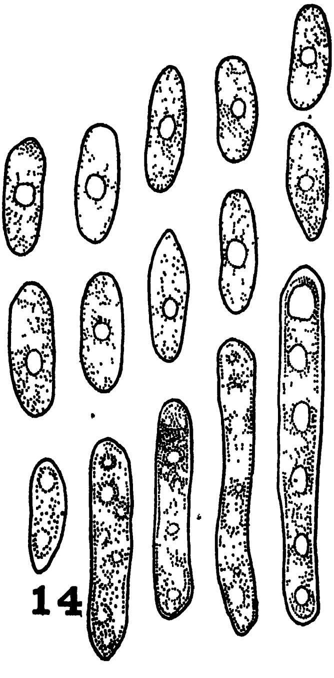

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PLATE II

LEGEND FOR PLATE III

FIGURE 15 —Shows character of the plasma of spores of *C gloeosporioides*

FIGURE 16 —Spores of *G limetticolum* showing contraction of the plasma

FIGURE 17 —Spores of *G limetticolum* showing different forms and shapes which occur in culture media

FIGURE 18 —Spores of *C gloeosporioides* showing various forms and shapes which occur in culture media

FIGURE 19 —Conidiophores of the avocado culture of *C gloeosporioides*

FIGURE 20 —Conidiophore of the mango culture of *C gloeosporioides*

FIGURE 21 —Conidiophore of the lime fungus *Gloeosporium limetticolum*

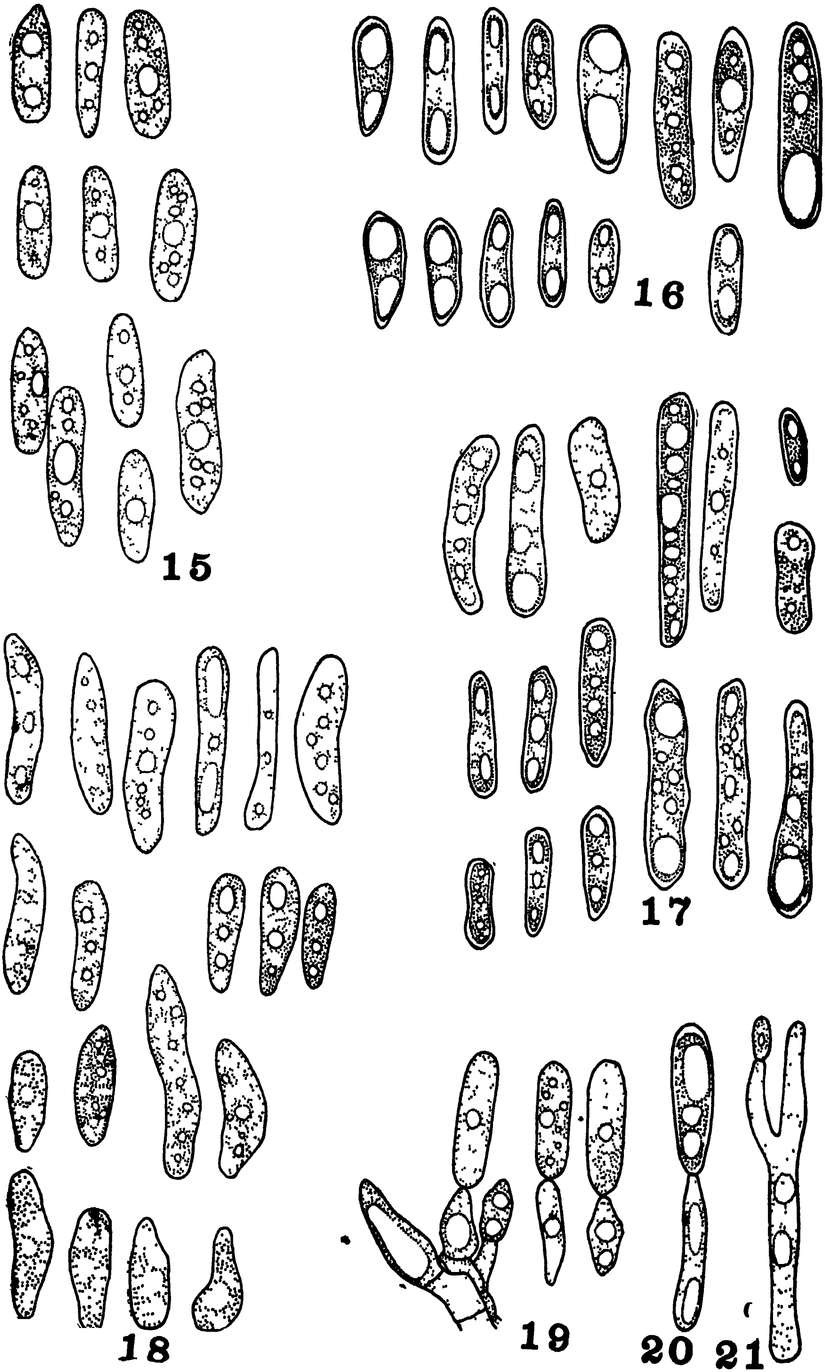


PLATE III

LEGEND FOR PLATE IV

FIGURE 22.—*Colletotrichum gloeosporioides* on +15 nutrient agar. Culture from orange.

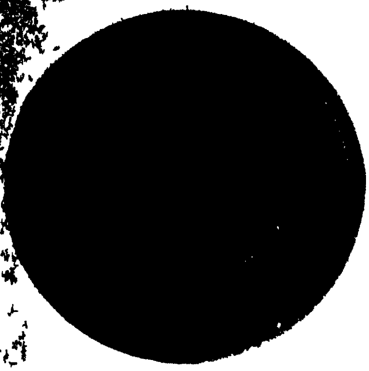
FIGURE 23.—*C. gloeosporioides* on −15 nutrient agar. Same culture as in Fig. 22.

FIGURE 24.—*C. gloeosporioides* on +15 agar. Culture from lime.

FIGURE 25.—*C. gloeosporioides* on −15 agar. Same culture as in Fig. 24.

FIGURE 26.—*C. gloeosporioides* on maltose agar. Culture from orange.

FIGURE 27.—*C. gloeosporioides* on maltose agar. Culture from lime.



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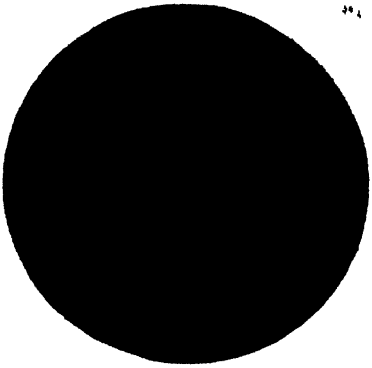

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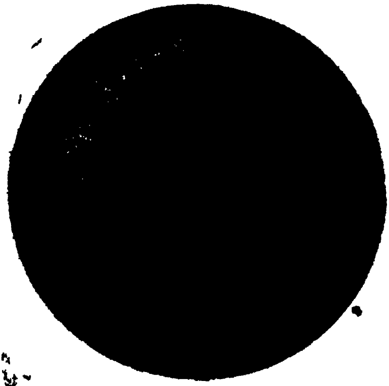

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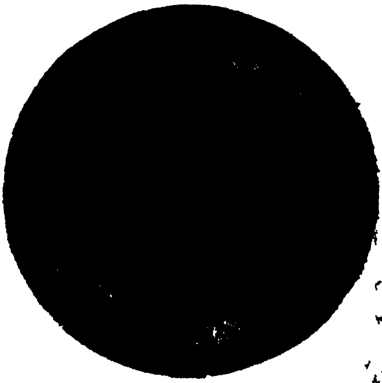

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PLATE IV

LEGEND FOR PLATE V

FIGURE 28.—*Gloeosporium limetticolum* on maltose agar

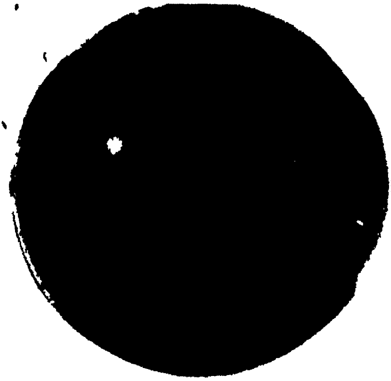
FIGURE 29.—*G. limetticolum* on maltese agar. Different culture from Fig. 28.

FIGURE 30.—*G. limetticolum* on lactose agar.

FIGURE 31.—*C. gloeosporioides* on lactose agar. Culture from mango.

FIGURE 32.—*C. gloeosporioides* on sucrose agar. Culture from mango.

FIGURE 33.—*C. gloeosporioides* on sucrose agar. Culture from avocado.



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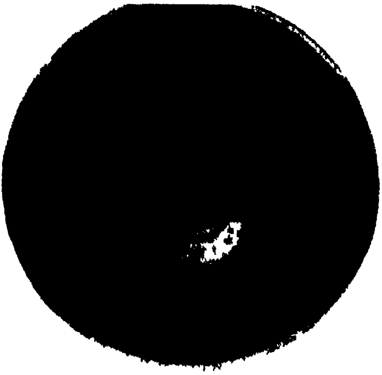

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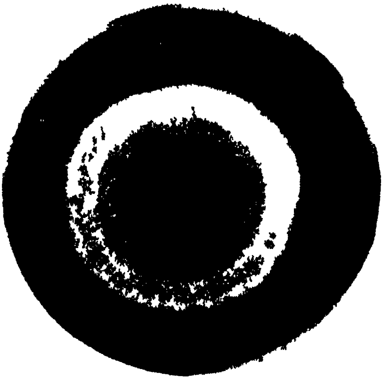

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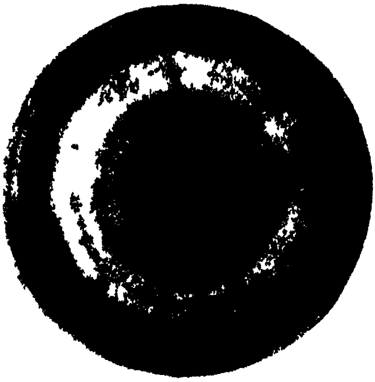

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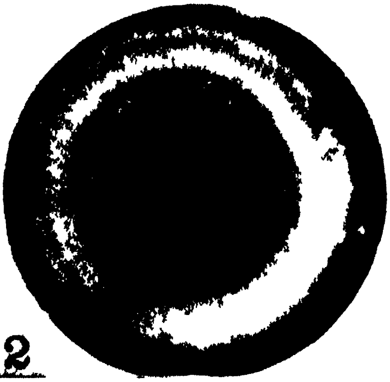

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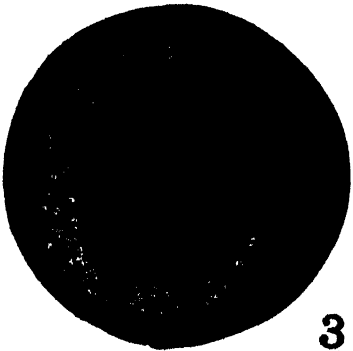

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PLATE V

LEGEND FOR PLATE VI

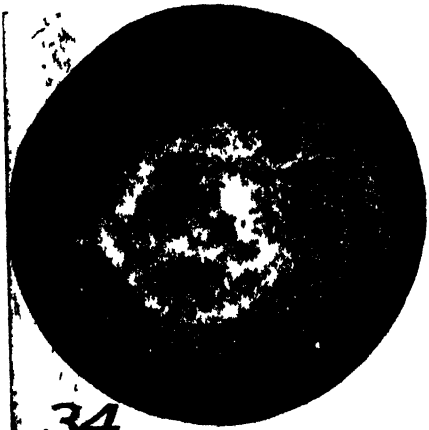
FIGURE 34.—*C. gloeosporioides* on oat-meal agar. Culture from avocado.

FIGURE 35.—*C. gloeosporioides* on glucose agar. Culture from avocado.

FIGURE 36.—*C. gloeosporioides* on corn meal agar. Culture from avocado.

FIGURE 37.—Canker or fruit spot of the mango.

FIGURE 38.—Canker or fruit spot of the lime.



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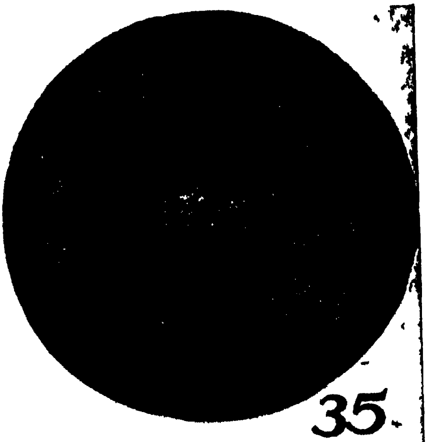

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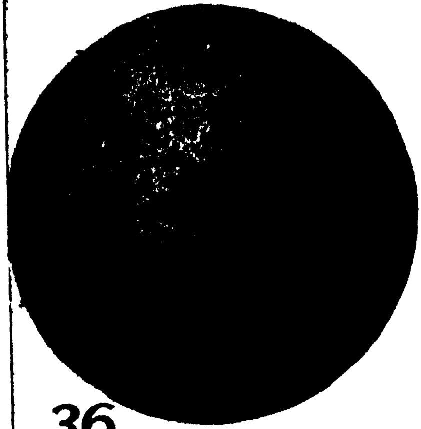

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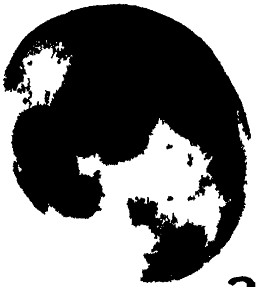

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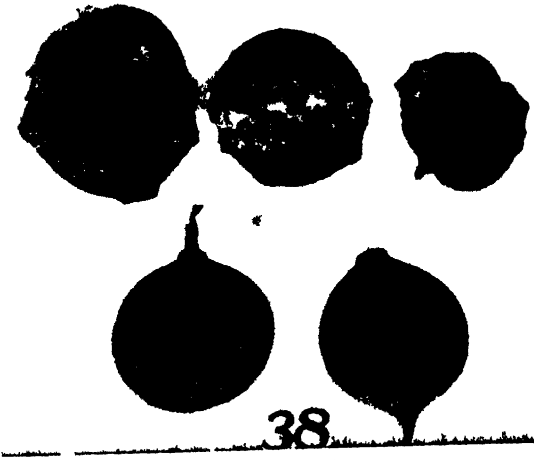

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PLATE VI

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Virgilio Colón Frías, B. S. ------Assistant Chemist

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Policarpo González, B. S.--------Plant Breeder
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DIVISION OF BOTANY AND PLANT PATHOLOGY

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J. A. B. Nolla, M. S.------------Assistant Pathologist

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José I. Otero--------------------Secretary
Luis H. Castellón---------------Translator
Silvestre Cruz-------------------Clerk
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[1] As of date of issue.
[2] Vacant.

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PARTS OF FOUR LEAVES OF SUGAR CANE

The first three show the most common types of injury. The fourth shows the blotch type. Also a young rattoon plant showing severe infection.

Drawn by Mario Brau

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THE EYE-SPOT DISEASE OF SUGAR CANE

MELVILLE T. COOK, Chief of Division of Plant Pathology

The eye-spot disease of sugar cane became serious in Porto Rico in 1922–23. Like most diseases which suddenly appear as menace to a crop it was referred to by the growers as a new and mysterious disease and was given several local names. Along the north coast it was frequently referred to as the Manatí disease because it was first found n the vicinity of Manatí. Along the south coast it was sometimes referred to as Santa Rita disease although that name was not used so extensively as Manatí. Fortunately these two names have gone out of use and the disease is now generally known as "eye spot", a name which is very generally used in other cane-growing regions of the world. The first studies made by the writer showed considerable variations in the spots and in size of the spores which led us to suspect that that spotting might be due to two-species of organism causing the disease but later studies have shown that this is not true.

Although the disease was at first referred to as new and mysterious, the studies made by the writer very soon showed that it is the common "eye spot" which is caused by a fungus (*Helminthosporium sacchari* Butler) and is well known in other parts of the world. It was first reported from Porto Rico by Johnston and Stevenson (8) in 1917, but it was no doubt present on the Island many years previous to that date. Its sudden appearance as a severe disease in Porto Rico was no doubt due to the growing of an increased acreage of susceptible varieties and to the climatic conditions in 1922–23 which were especially faborable to the growth of the fungus. In 1923–24 the disease was less severe, due to unfavorable conditions but it has been quite severe during the following years. The threatening character of this disease lead us to make studies which have been carried out during a period of four years and are recorded in this paper.

HISTORY

The prevalence, wide distribution and general character of this disease give ample reason for believing that it is very old although we have no authentic records previous to 1892 when it was first reported and described from Java by L. van Breda de Haan (5) who demonstrated that it was infectious and due to a fungus which he named *Cercospora sacchari.* A more complete account of the disease and a colored plate was published from Java in 1898 by Wakker and Went (18). In 1901 the disease was discussed in another publication from Java by Dickhoff and Hein.

In 1907 the disease was reported from Hawaii by Lewton-Brain (15) who stated that the disease had been known previously as "rust". In 1909 the disease was again reported from Hawaii by Cobb (3) who also published a colored plate which corresponds quite well to the disease as found in the greater part of Porto Rico, but his spore drawings are of *Helminthosporium.* In 1922 Larsen (9) reported the isolation of the fungus and the reproduction of the disease by spraying cane leaves with a spore infusion.

In 1913 it was reported and described from India by Butler (2) under the name of *Helminthosporium sacchari* who comments on previous work as follows:

> "In Hawaii it has been briefly described by Cobb. From the figures published in Wakker and Went's well-known textbook of sugar-cane diseases, it appears probable that this fungus is really a *Helminthosporium* and not a *Cercospora.* A comparison of the two fungi has not been possible and could alone settle the question of their identity."

Butler's nomenclature is very generally followed by mycologists and plant pathologists. Butler reported that the disease had "not been found to damage the crop materially".

The disease was first reported from Porto Rico in 1917 by Johnston and Stevenson (8) who evidently did not consider it of much importance. It was next reported from Porto Rico by the writer (4) in 1924 in a preliminary paper as a disease which threatened to be of major importance.

The latest publication is a series of papers from Hawaii by Lee (7, 10–14, 16, 17) and others in which various phases of the disease and discussed. These publications will be referred to from time to times in this paper. In the first of this series Lee (10) calls attention to the fact that early publications indicate that the disease probably existed in Hawaii as early as 1854, that it was considered as serious and was known as "fire blight". This is 39 years earlier than the first authentic record by van Breda de Haan.

Although there is reason to believe that the disease is widely distributed throughout the sugar-cane-growing regions of the world the only reports of serious outbreaks are from Hawaii and Porto

Rico and the only important varieties that have proved, especially susceptible in Porto Rico, are D. 109 and F.C. 306. H. 109 has been introduced into Porto Rico but has not been grown extensively. It is less susceptible in Porto Rico than D. 109 and F.C. 306.

The preceding discussion includes references to the most important publications but there are many other brief references which show the wide distributions of the disease throughout the sugar-cane-growing countries of the world. These records show that the disease is known in Java, Hawaii, India, Philippines, Formosa, and Southern United States. It has been reported from West Indies, from Cuba, Jamaica, Santo Domingo, Barbados, Trinidad and Reunion.

SYMPTOMS

The eye spot is usually well defined and characteristic but is subject to many variations, depending on variety, age, severity of infection, climatic and possibly other factors. The disease occurs on the lower half of the blade, sometimes attacking the sheaths but rarely attacking the outer half of the leaf except in the case of young plants, when the entire leaf may be attacked.

The disease usually starts as very small reddish, occasionally black spots. If the variety is very resistant, this character may disappear with the growth of the plant. If the variety is susceptible, the spot increases in size and developes other colors. Most spots on susceptible varieties are red when young but usually develop black centers and yellowish borders. The arrangement of these colors and the elongated, pointed form have given rise to the common name "eye spot". However, the spots are not uniform in either shape or color. Any one of the colors may predominate. Sometimes the spot remains red until one-fourth inch in length before showing a black center. Sometimes the colors have rather definite outlines and sometimes they blend. Sometimes the spots have the definite eye form and at other times they take the form of long narrow black streaks of various lengths; usually one-fourth inch to 3 inches but occasionally more. Sometimes they are long, dark in color and of a rather irregular outline. Sometimes they unite, usually at the end. In young spots, the colors are usually bright and clear but as the spots grow old the colors become dull and almost disappear with the dying of the leaf. As the spots grow old, they usually develope ashy-colored centers as a result of a dying of the central tissues. In the case of the more susceptible varieties, such as F.C. 306 and D. 109, the entire leaf may dry, and in the case of severe outbreaks it is not uncommon for three-fourth or more of the leaves to be killed. Entire fields become brown, except for a few green leaves at the tops of the plants. The spots may occur on any part of the lower half of the leaf from midrib to margin but do not occur on the midrib. In the case of severely infected young plants and seedlings the entire plant may be varying shades of red, the tips and outer leaves die and become brown very soon and in many cases the plant is killed. In some cases the spots are blunt, with a predominance of red and purple colors which darken with age. Sometimes the spots coalesce, become irregular and develop into blotches which may enclose small areas of apparently healthy green issues. The margins of these blotches are frequently yellow. These blotch characteristics were originally attributed to the so-called "Santa Rita" disease, but a more extensive study indicates that we have but the one species of the fungus. Therefore, the blotching must be considered one of the variations of the disease symptoms. Although the characteristic blotchings are most common on the south coast, they do occur in other parts of the Island and the writer has produced them under green-house conditions by heavy infection of the young canes. The top-rot symptom which is described in publications from Hawaii is rare in Porto Rico but the "fire blight" which is also described in the Hawaiian publications is quite common, especially on D. 109 when grown on the higher elevations. Many of these variations are no doubt due to varieties and to climatic conditions, but some of them may be due to soil conditions as previously referred to by the writer (4) or to the presence of other fungi which are more or less common on the spots.

The disease attacks the lower half of young leaves of growing cane while they are unrolling. The spores are apparently carried by the wind and fall into the tops of the cane, and since the arrangement of the leaves is especially favorable for the collection of moisture, the conditions are most favorable for the growth of the fungus.

The *ring spot* of sugar cane is due to an entirely different fungus (*Leptosphaeria sacchari* J. van Breda de Haan). It is possible that this disease might be confused with the "eye spot" by inexperienced observers, but a little study will enable any one to distiguish the two diseases in most cases. This spot occurs on the outer half of the older leaves. The spots are much broader and shorter than the eye spots and are usually not more than two or three times as long as wide, more or less irregular in outline, and tending to unite, so that in many cases the outer-one-fourth or one-half of the old leaves are entirely dead. The ring spots are brownish or reddish but the colors are never so bright as in the eye spots. Gray dead centers develope very early so that in a very short time the spots show as large gray areas surrounded by a narrow zone of brown, black or reddish tissue.

LOSSES

It is extremely difficult to estimate the losses due to a disease of this type with any degree of accuracy, but it is very evident that the losses must be considerable in the cases of the severe outbreaks. Since the greater part of the manufacture of sugar is in the leaves of the plant, the destruction of any considerable part of the leaf must necessarily reduce the working power of the plant proportionately. And since the disease attacks the leaf so early in its development, the areas that are destroyed have practically no part in the manufacture of sugar or in furnishing elaborated foods for the growth of the plant. Therefore, the greater the destruction of the leaf tissue, the greater the reduction in growth and manufacture of sugar. The writer has seen very large areas of B. 109 and F.C. 306 in which 80 per cent of the leaves were entirely dead long before maturity. Furthermore, the disease frequently kills canes varying in height from a few inches to four feet. In one field of F.C. 306, fifty-seven per cent of the canes were killed. In the case of very susceptible varieties, many young canes of ratoon growths are killed. Seedlings are frequently destroyed in great numbers. The writer has seen outbreaks in the seedling flats which resulted in the death of many hundred seedlings, and Mr. Robert L. Davis of the Porto Rico Agricultural Experiment Station writes that in the case of one variety "only 250 out of 1,106 survided". When young canes are killed, they are very frequently attacked by the rind disease (*Melanconium sacchari* Massaee) which finishes the work of destruction, although it is primarily a saprophyte.

THE ORGANISM

The organism was described by Butler **(2)** from India in 1913 as follows:

> "The infected leaves first show small red spots, which spread rapidly, chiefly in the longitudinal direction and, especially towards the tip of the leaf, may run together to form long streaks. The center of the spot soon changes to a dirty straw color, around which the margin remains red for a time and then changes to dark brown. The spots occur equally on the midrib, where they may be confused with those caused by the leaf form of *Colletotricum falcatum* and on the thinner part of the leaf. When numerous, they cause death of the leaf tissues beyond the limits of the spots; the tip of the leaf often withers completely and there are many long withered strips down the margins.
>
> "The sporophores are stout, erect, rather rigid hyphae, which arise from the peripheral cells of the stromata (Pl. VI, Fig. 4). They are usually unbranched,

8 to 10 septate, dark greenish-brown below, paler above and several times bent or 'geniculate'. Spores are produced at each bend and at the apex, the lowest being due to the spores being always apical at first and being then pushed to one side by continued growth of the sporophore from just below the insertion of the spore. The sporophores are 100 to 190 microns long, by 5.5 to 7.5 microns broad.

"The spores (Pl. VI, Fig. 5) are borne single and readily fall off. They are cylindrical or long elliptical in shape, with very thick walls, and divided into from 4 to 11 compartments by broad thick partitions. The colour varies from olive green to brown and the size from 35 to 60 microns long, by 8.5 to 12 microns broad.

"*Helminthosporium sacchari* Butl. n. sp. Maculis amphigenis, elongatis, initio, rubris, dein avellaneis, vel stramineis ac ferrugineo-marginatis, 3–25 × 2–6 mm.; caespitulis minutis, atris; hyphis fertilbus erectis simplicibus, 3–10—septatis, geniculatis, olivaceo-brunneis, apice pallidioribus, 100–190 × 5.5–7.5 microns; conidiis acrogenis, cylindraceis vel oblongo-ellipticis, utrinque rotundatis, 3–10 septatis, carssissime tunicatis, olivaceo-brunnels, 35–60 × 9.5–12 microns."

The description given by Johnston and Stevenson reads as follows:

"Hyphae dark, cobwebby, arising from the center of an elongated brown spot on the leaf-blade; sporophores more or less erect with single terminal spores; spores several septate with very thick walls, rounded at both ends, 32–90 × 9–14 microms, on conidiophores 120–160 mm. long."

The writer measured several hundred spores (Fig. 1) the minimum being 22 × 6.6 u while the maximums were 92 × 13 u and 88 × 15 u. The average was 58.7 × 11.1. The septa ranged from 3 to 11. The minimum sporophore (Fig. 2) was 44 u while the maximum was 337.5 u. These measurements were made from spores and sporophores from leaves of 23 varieties of cane which had been in moist chamber 24 hours. It was impossible to correlate the measurements with the varieties of cane.

The size of the spores appear to depend primarily on humidity. Both in the field and laboratory, under dry conditions, the spores were few and large while under moist conditions they were many and small. However, in the laboratory the spores formed in moist chamber during the first 24 hours were usually larger than those for any succeeding 24 hours.

The young sporophores are more or less straight and the spores are borne apically. Possibly it would be better to say that the youngest spore is borne apically. Following the formation of the first spore, there is a new growth starting just back of the point of attachment which extends forward and at a slight angle. A new spore is formed at the tip of the new growth and another new growth is started. This occurs repeatedly and results in a geniculate sporophore with scars at the angles. The attachment of the spores is so delicate that very few are seen in place.

LABORATORY STUDIES

The spores are very brittle and fall from the sporophore very readily. Therefore, it is difficult to find them on leaves fresh from the field unless the leaves are collected early in the morning and handled carefully. However, they can be secured in great abundance on leaves kept in a moist chamber for 24 hours. However, the spores produced each succeeding 24 hours are likely to be smaller than the preceding. Furthermore, the spores grown in culture are very generally smaller than those found in nature. The spores are borne more abundantly on the lower than on the upper surface of the leaf. The sporophores vary greatly not only in size but also in each group or cluster. When single they were usually longer and more spores are produced than when in groups. They are geniculate, a single spore being produced from the convex side of the bend or angle. The spores originate from the apex, a new growth starts just below the spore and is forced slightly to one side, causing the first bend. This is repeated and results in alternate right and left bends.

The spores germinate very freely in water (Fig. 4) usually with a single tube and usually from one end of a spore. If grown on a piece of glass, the tube twists around and grows in various directions (Fig. 6) but if grown on the leaf it advances but a short distance and then penetrates at a point between the veins or fibro-vascular bundles without regard to the presence or absence of stomata (Figs. 7 and 10). Spores will germinate on and penetrate either surface of the leaf, but inoculation experiments have shown that the upper surface is more susceptible than the lower surface. This was demonstrated by applying agar containing spores at various points along the surfaces of the leaf or along the entire surface. This film of agar was removed after 48 hours. These experiments were repeated a number of times, and the plants kept in a greenhouse. The spots were always more numerous on the upper than on the lower surface. Very young leaves are susceptible from base to tip on both surfaces, but as they grow older they gradually loose their susceptibility, beginning with the tip; the upper surface remaining susceptible longer than the lower surface. The upper surface of a reasonably young leaf is susceptible nearer the tip than the under surface of the same leaf. The sporophores will also germinate and are probably as important in spreading the disease as the spores.

The penetration of the leaf by the germ tube is very quickly followed by a discoloration and formation of a spot (Figs. 7 to 10). In some cases the spot can be detected by the unaided eye within 30 hours after inoculation. This spot increases in size, the greater growth being lengthwise and between the larger fibro-vascular bundles. It appears to be rather difficult for the fungus to penetrate the fibro-vascular bundles, although this does occur.

The germ tube appears to be able to penetrate at any point between the fibro-vascular bundles or veins. It was not seen to penetrate immediately over or under a fibro-vascular bundle, nor into a stomata. The first growth of the mycellium after penetration is in the parenchyma tissues and is either inter- or intra-cellular (Fig. 12) and the septa are comparatively few. The spots increase in size, especially in length with age, the discolorations usually extending beyond the range of the fungus. The mycelium becomes more and more abundant and the septa more numerous. It frequently acquires the power to penetrate the fibro-vascular bundles (Figs. 13 to 15), but age and the resistance of the hard walls of the cells of the fibro-vascular bundles results in the formation of masses of fungus cells resembling sclerotia, usually just within the epidermis and next to the fibro-vascular bundles (Figs. 9 and 11). The resistance exerted by the hard cell walls of the fibro-vascular bundles appear to be the stimulus which leads to the formation of septa and the sclerotia-like growth. This growth breaks, through the epidermis and forms sporophores. It also frequently produces a growth which spreads over small areas of the surface of the leaf (Fig. 11). The sporophores were also seen growing out through stomata.

A careful study was made of the structure of the leaves of a large number of varieties and a comparison of the most resistant with most susceptible varieties indicated that the varieties with numerous, close fibro-vascular bundles were more resistant than the varieties in which the fibro-vascular bundles were rather widely separated by large quantities of parenchyma tissue. This is in harmony with the large amount of mycelium in the parenchyma as compared with the fibro-vascular bundles.

INOCULATION EXPERIMENTS

The inoculations were made in both greenhouse and field for the purpose of determining the relative susceptibility of the many varieties. Inoculations are easily made either by the use of spore infusions applied with an atomizer or by pouring the infusion into the tops of the cane plants. The simplest and easiest method, was the application in the top of the cane by means of a glass tube. When the spore infusions are applied to the base of the young leaves, infections can be obtained in very nearly 100 per cent of the cases, but if applied to the old leaves or tips of leaves the results are usually negative. The best time for inoculation is late in the afternoon, probably because the plants retain the moisture during the night better than under the bright sunshine of the day. It is not necessary to injure the surface of the leaf. Infections may be obtained at any season of the year but the plants respond more readily during the cooler months of November, December, January and February and March, which is the season the disease is most abundant in the fields. During the warm, summer months, infections are easily obtained, but under conditions here at the Insular Experiment Station there is very little spread of the disease from the infected to the neighboring plants. All varieties can be infected, but in the most resistant varieties the spots can not be seen without close study. Uba may be considered most resistant, and close examinations made 48 hours after inoculation showed minute black spots. Varieties do not always respond in the same manner even though the experiments are made in the same place and as nearly as possible under the same conditions. This is well shown in the following tables:

TABLE I

GREENHOUSE INOCULATION

The groups are arranged in order of susceptibility, the most susceptible first

D. 433
F.C. 306
D. 109

P.R. 460
B.H. 10(12)

B. 67
D. 109
Ba. 11569
P.R. 433

B. 6450
D. 109
P.R. 729

Ba. 6032
D. 448

F.C. 214
S.C. 12(4)
B.H. 10(12)

P.R. 328
P.R. 329
B. 3412
H. 109
D. 1135
P.R. 492
P.R. 440

Cristalina
P.R. 333
Uba

Badila
P.O.J. 105

TABLE II

GREENHOUSE INOCULATION

The groups are arranged in order of susceptibility, the most susceptible first

F.C. 306
D. 109

H. 109
P.R. 433
Ba. 11569
D. 448
D. 109

Ba. 6032
P.R. 329
F.C. 214

D. 1135
B.H. 10(12)

P.R. 440
P.R. 328
P.R. 492

Yellow Caledonia
B. 67
P.O.J. 105
P.R. 440

B.H. 10(12)
S.C. 12(4)
Cristalina
B. 3412
P.R. 333
Badila
Uba

In Table I it will noted D–109 was used in three and B.H. 10(12) in two different containers with different results, although the containers were separated by spaces of less than 10 feet.

It will also be noted that the results in the two tables are slightly different. This is especially true in the case of B. 67. However, F.C. 306 and D. 109 can be depended on as very generally showing the greatest susceptibility.

TABLE III

PLANTS KILLED IN GREENHOUSE AS RESULT OF HEAVY INFECTION

These plants were grown in 5 gallon oil cans and four buds planted in each can.

	First record	Second record	Third record
D. 117	all	—	—
Cristalina	5	1	1
Ba. 6032	1	2	all
D. 448	2	—	all
D. 433	1	—	—
B.H. 10(12)	—	4	—
B. 6450	—	1	2
P.R. 711	—	1	1
Badila	—	1	—
Ba. 11569	—	1	—
F.C. 306	—	1	—
P.R. 328	—	1	—
B. 3412	—	1	1
H. 109	—	1	—
P.R. 460	—	—	2
P.R. 433	—	—	1
P.R. 704	—	—	1
P.R. 440	—	—	1

In comparing the results given in Table III with the results of Tables I and II it will be readily seen that the varieties showing the greatest leaf infection in Tables I and II did not show the highest mortality. However, the number of plants used in Table III was so small that no definite conclusions can be drawn from this experiment. Furthermore, the field observations showed a greater mortality in FC–306 than in any other variety.

TABLE IV

INOCULATION MADE ON PLOT WITH OVERHEAD IRRIGATION

Records made every week for six weeks

xxxxx = very severe; xxxx = severe; xxx = medium; xx = slight; x = very slight

Rank	Variety	First record	Second record	Third record	Fourth record	Fifth record	Sixth record
1.	I . 306	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
2.	I 109	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
3.	I 109	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
4.	I . 433	xxx	xxxx	xxxx	xxxx	xxxx	xxxx
5.	I . 460	-----	xxxx	xxxx	xxxx	xxxx	xxxx
6.	I . 328	xx	xxx	xxx	xxx	xxx	xxxx
7.	I 3412	xxx	xxx	xxx	xxx	xxx	xxx
8.	F . 440	x	xxx	xxx	xxx	xxx	xxx
9.	E I. 10(12)	-----	xx	xx	xx	xxx	xxx
10.	E 6450	-----	-----	-----	-----	xxx	xxx
11.	P . 792	x	xx	xx	xx	xxx	xxx
12.	. 329	x	xx	xx	xx	xx	xx
13.	. 214	xx	xx	xx	xx	xx	xx
14.	433	x	x	x	x	x	x
15.	67	-----	-----	-----	-----	xxxxx	xxxxx
16.	talina	-----	-----	-----	-----	xxxxx	xxxxx
17.	. 726	-----	-----	-----	-----	xxx	xxx
18.	6032	-----	-----	-----	-----	xxx	xxx
19.	11569	-----	-----	-----	-----	xx	xx
20.	ila	-----	-----	-----	-----	xx	xx
21.	448	-----	-----	-----	-----	-----	x
22.	1135	-----	-----	-----	-----	-----	-----
	. 492	-----	-----	-----	-----	-----	-----
	117	-----	-----	-----	-----	-----	-----
23.		-----	-----	-----	-----	-----	-----

Tables V, VI and VII are made from a field at the entrance of the Insular Experiment Station. The land is low, the humidity high and the temperature favorable during the winter months. The disease appeared here in advance of any other place on the Insular Experiment Station and was more severe.

TABLE V

xxxxx = very severe; xxxx = severe; xxx = medium; xx = slight; x = very slight

Rank	Variety	First record	Second record	Third record
1.	F.C. 306	xxxxx	xxxxx	xxxxx
2.	D. 109	xxxx	xxxx	xxxx
3.	P.R. 329	xxxx	xxxx	xxxx
4.	B. 3412	xxxx	xxxx	xxxx
5.	D. 448	xxxx	xxxx	xxxx
6.	F.C. 214	xxx	xxx	xxxx
7.	D. 433	xxx	xxx	xxxx
8.	B.H. 10(12)	xxxx	xxx	xxx
9.	H. 109	xxx	xxx	xxx
10.	P.O.J. 36	xxx	xxx	xxx
11.	M. 36	xxx	xxx	xxx
12.	P.R. 440	xxx	xxx	xxx
13.	Cristalina	xx	xx	xxx
14.	Yellow Caledonia	xxx	xx	x
15.	D. 1135	xx	xx	xx
16.	P.R. 492	xx	xx	xx
17.	P.O.J. 228	xxxxx	-----	-----
18.	Ba. 6032	xxxx	x	-----
19.	P.R. 460	xxx	x	-----
20.	D. 117	xxx	x	-----
21.	B. 67	xx	x	-----
22.	P.R. 328	xx	x	-----
23.	P.R. 729	xx	x	-----
24.	B. 6450	x	x	-----
25.	P.O.J. 234	xx	-----	-----
26.	Ba. 11569	xx	-----	-----
27.	S.C. 12(4)	xx	-----	-----
28.	Uba	-----	-----	-----

Table V is a composite made up from studies following inoculation. The first reading was made 4 days after inoculation and the second two months later and the third one month after the second.

A comparison of Tables IV and V shows that although F.C. 306 and D. 109 are the most susceptible and that Uba is the most resistant, the other varieties do not occupy the same positions in the two tests.

TABLE VI

NATURAL INFECTION IN THE SAME FIELD

December 8th, 1926

F.C. 306	xxxxx
Ba. 6032	xxxxx
D. 109	xxxx
P.R. 329	xxxx
F.C. 214	xxxx
D. 216	xxxx
P.R. 328	xxxx
H. 109	xxxx
B.H. 10(12)	xxx
M. 36	xxx
P.R. 440	xxx
B. 6450	xxx
P.O.J. 36	xx
D. 433	xx
D. 1135	xx
P.R. 492	xx
P.R. 460	xx
B. 67	xx
P.R. 729	x
P.O.J. 234	
P.O.J. 228	
D. 117	
Ba. 11569	
Uba	

TABLE VII

NATURAL INFECTION IN THE SAME FIELD

January 14th, 1927

F.C. 306	xxxxx
D. 109	xxxxx
Ba. 6032	xxxxx
Y. Caledonia	xxxxx
H. 109	xxxx
P.O.J. 36	xxx
M. 36	xxx
B. 3412	xxx
P.R. 440	xxx
P.R. 328	xxx
P.R. 329	xxx
F.C. 214	xxx
Cristalina	xx
P.R. 729	xx
B.H. 10(12)	xx
D. 433	xx
D. 418	xx
P.R. 492	x
P.R. 460	x
B. 67	x
Ba. 11569	x
B. 6450	x
P.O.J. 228	trace
P.O.J. 234	trace
D. 1135	trace
D. 117	trace
Uba	

A comparison of Tables V, VI and VII shows that although the varieties do not occupy exactly the same relative positions, F.C. 306 and D. 109 are most susceptible and that Uba is the most resistant.

TABLE VIII

This field was part of the property of Central Cambalache. It had been planted to varieties for the purpose of studying resistance of varieties to mosaic but became infected with *Helminthosporium sacchari*. This field is located on low land, near the coast.

Variety	Severity	Remarks
F.C. 306	xxxxx	
D. 109	xxxxx	
P.R. 329	xxxxx	
D. 448	xxxxx	
B. 3405	xxxxx	
B. 3412	xxxxx	
P.R. 662	xxxxx	
P.R. 433	xxxxx	Very few living leaves.
B. 67	xxxxx	Leaves yellow, long narrow streaks.
Rayada	xxxxx	Apparently less damage than on others.
H. 109	xxxx	
D. 625	xxx	
B. 208	xxx	
P.R. 545	xxx	No great damage.
S.C. 12(4)	xx	Many small spots. No great damage.
Ba. 11569	xx	Many small spots. No great damage.
P R. 328	xx	
P.R. 414	xx	
P R. 440	xx	
P.R. 561	xx	
D. 117	xx	Very small spots.
B. 3696	x	Very few small spots.
Cristalina	x	
L. 511	x	Very few spots.
P.R. 417		Occasional spot.
P.R. 492		Occasional spot.
P.R 483		Occasional spot.
B.H. 10(12)		Occasional spot.
P.R. 260		Occasional spot.
Uba		Practically immune.

TABLE IX

In another record at a different date, from the same field; also a grouping with reference to age, purity and sucrose content of the varieties. The field data was taken by the writer. The information on age, purity and sucrose was furnished by Mr. Pedro Olivencia of Central Cambalache.

Variety	Severity	Remarks	Age in months	Purity	Sucrose
B. 3412	xxxxxx	Most severe of all	12	86.87	15.35
P.R. 433	xxxxx	Most leaves die	11	91.19	16.87
B. 67	xxxxx	Most leaves very yellow	12	90.63	17.22
P.R. 329	xxxxx		12	88.70	15.79
P.R. 662	xxxxx		11	90.58	17.80
F.C. 306	xxxxx		12	79.01	13.54
B. 3405	xxxxx		12	80.70	12.28
Rayada	xxxxx		12	83.46	15.61
D. 448	xxxxx		12	90.40	19.12
P.R. 545	xx	No great damage	12	83.38	14.68
B. 208	xx		12	86.90	14.40
P.R. 440	xx	Many small spots	12	88.49	15.00
P.R. 561	xx	Many small spots	12	79.18	13.92
P.R. 414	xx		12	86.90	13.61
P.R. 328	xx	Many small spots	12	84.88	15.11
P.R. 569	xx	Very small spots	12	90.40	17.37
H. 109	xx	Many small spots	--	-----	15.51
S.C. 12(4)	xx	Many small spits	12	87.30	13.85
P.R. 412	x	Resistant, slight infection	12	72.08	12.63
Cristalina	x	Resistant, few small spots	11	89.22	15.48
D. 117	x	Resistant, many small spots	15	84.13	15.06
B. 3696	x	Resistant, very few small spots	12	88.24	15.31
L. 511	x	Very resistant	14	86.50	15.65
B.H. 10(12)	x	Very resistant	12	76.91	13.85
D. 433	x		15	81.29	14.49
P.R. 260		An occasional spot	12	86.02	15.70

A comparison of the Tables VIII and IX is not possible because they do not record exactly the same varieties but they do show somewhat the same relationship of hosts to the disease.

Table IX also shows a grouping with reference to purity and sucrose, but these figures are only approximately correct as other analyses where no field studies were made have given different results. These variations in purity and sucrose content are due to factors which do not come within the scope of this paper. They indicate that there may be some relationship between susceptibility and resistance to purity and sucrose content. However, it also appears that there are other factors, such as climatic conditions and structure which are more important.

VARIETAL SUSCEPTIBILITY AND RESISTANCE

A study of these tables and our notes on field observations shows very definitely that F.C. 306 is the most susceptible commercial variety grown in Porto Rico. D. 109 is a close second. H. 109 can be placed third in the list but is much more resistant than D. 109. Uba is the most resistant variety grown on the Island. The records on the other varieties show more or less variations but they can be grouped as follows:

F.C. 306
D. 109
H. 109

D. 433
P.R. 460
B.H. 10(12)
B. 6450
Ba. 6032
D. 448
F.C. 214
P.R. 329
Yellow Caledonia

B. 67
P.R. 729
P.R. 328
B. 3412
P.R. 440
D. 117

S.C. 12(4)
D. 1135
P.R. 492
P.R. 333
Cristalina
Badila

P.O.J. 105
P.O.J. 36
P.O.J. 228
P.O.J. 234
M. 36

Uba

In general it may be said that the disease is so severe on F.C. 306 and D. 109 under most conditions in Porto Rico and that we cannot recommend their use. H 109 is more resistant but cannot be recommended. B.H. 10(12) and S.C. 12(4) which may be looked upon as the leading varieties in Porto Rico at this time are fairly resistant under most conditions in Porto Rco, but the writer has seen several severe outbreaks of the disease on B.H. 10(12) and a few severe attacks on S.C. 12(4). Although Uba is so resistant that for a time the writer considered it practically immune, one field was found in which this variety was heavily infected and a few fields in which there was a slight infection.

A comparative study of the structure of the leaves of a large number of varieties was made and it was found that resistance was correlated to a greater of less degree with structure, although this may not be the only factor involved. Varieties in which the fibro vascular bundles of the leaves were closely placed were more resistant than those varieties in which they were widely separated by parenchyma tissue. This is in harmony with the fact that the fungus

penetrates between the veins of the leaf and makes its first growth and in fact most of its growth in the parenchyma tissue.

A limited study was made of the roots but no injuries were traced to *H. sacchari*. Cultures of the organism were applied to the roots of growing cane in the greenhouse but we failed to find any evidence that the organism attacks the roots.

CLIMATIC FACTORS

Very early in our studies on this disease, it became evident that there were three very important factors in its severity: variety, temperature and moisture. The question of variety has already received consideration in the preceding pages.

Although the disease is much more severe in Porto Rico during the winter than during the summer months, it can be found at all times during the year. Fortunately, the U. S. Weather Bureau has excellent rainfall and temperature records for the three points where we made our studies. Tables X and XI are made from these records and is an average for 1922 to 1926 inclusive (except for the temperature record at Río Piedras which covers only three years). Hydrographs were placed at two points on the property of Central Cambalache; one near the coast where the records contained in Tables VIII and IX were made and the other in the hills. The later instrument was removed to the Granja and was broken by the wind storm that swept over the Island July 23rd, 1926. We have no records of value from this instrument. Two instruments were placed on the property of the Fajardo Sugar Co.; one in the locality of high humidity and the other in a locality of low humidity, a hydrothermograph was placed in the field on the Insular Experimental Station Farm from which the records of Tables V, VI and VII were made. All these records have been of value in our studies, but the hydrograph records have not been satisfactory as we had hoped for when the work was started.

TABLE XI

SHOWING AVERAGE RAINFALL AND TEMPERATURE OVER FIVE YEARS (1922–26)

Except for Río Piedras, where the temperature covers three years only

AVERAGE RAINFALL

	Jan	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Río Piedras	4.65	5.17	4.35	4.44	3.10	6.55	10.56	7.50	6.68	6.44	7.26	6.35
Arecibo	4 24	6 94	3.88	4.40	1.50	3.24	4 21	5.20	4.82	4.38	5.88	7.22
Fajardo	2 75	3.71	2.84	3.01	2.83	3.68	4.48	6.99	4.07	7.65	8.29	8.33

AVERAGE TEMPERATURE

	Jan	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Río Piedras	73.1	75.1	74.4	75 7	77 3	77.8	77.7	78.7	78.8	78.2	76.8	75.2
Arecibo	73.7	73 9	75 8	77.6	79 5	80.0	80 4	81 1	80 9	79.7	77.9	74.7
Fajardo	77.1	76 5	77.1	78.9	80.9	81.6	82 0	82.4	82.3	81.2	79.8	77.8

The compilations from the U. S. Weather Bureau records (Tables X and XI) show a gradual decline in temperature from September to January and then a gradual rise until June. The coolest months are November to February inclusive and the warmest months are May to October inclusive. Of course the temperature was slightly lower during the night and somewhat higher during the day than is shown on the chart. The disease is most severe during November, December, January and February, and March the period of lowest temperature. The average rainfall for the same period is also shown on this chart. It will be readily seen that the greatest rainfall with one exception coincides fairly well with the period of low temperature. Our studies indicate that a low temperature and a high atmospheric humidity are most favorable for the development of this disease but it is very evident that the disease is more sensitive to variations in temperature than to variations in rainfall.

The thermograph records at Río Piedras showed the lowest temperature during the winter months and the highest during the summer, the most noticeable being about November 1st which was also the date of a rapid increase in the eye spot. The hydrograph showed a higher humidity during the summer months than during the winter months.

The hydrograph at Arecibo was placed near the ocean, where it was under the influence of a wind current from the ocean practically all the time, and showed a slightly higher humidity during the summer months. This is in harmony with the rain fall records although the ranges at Arecibo are not so pronounced as at other points. The average temperature records are lowest from December to March inclusive, the period of greatest severity for the disease.

At Fajardo, the range of lowest rainfall according to the U. S. Weather Bureau reports was from December to June inclusive and the lowest temperature from December to March inclusive, which was also the period of greatest severity for the disease. However, there was one record at Fajardo that was especially interesting. At one point (Paraiso) the rainfall ranged from 1.20 inches in March to 3.20 inches in October greater than the average for nine years for the Central zone. The disease was always more severe at this point than at two other points (Fortuna Centron and Santa Rita) where the local rainfall coincided quite well with the average for the Central zone.

However, a paper on "Relation of Temperature to the Growth of the Eye Spot Fungus" by Halma and Fawcett (6) was published in Phytopathology, August 1925, which has been valuable to us in our work; according to the studies of these workers the fungus makes its most rapid growth under laboratory conditions at about 84° F. It grows more slowly at both higher and lower temperatures, making no growth at temperatures above 95 and very slow growth at 56 degrees.

We do not have the equipment for extensive experiments on either temperatures or humidity, but the results obtained with the one thermograph here at the Experiment Station and a study of the disease in connection with the U. S. Weather Bureau records indicate that the organism makes its best growth with an average outdoor temperature ranging from 73 to 77 degrees F. which is lower than the optimium temperature in the laboratory experiments with the organism in Hawaii. Of course it must be remembered that Weather Bureau records are not made in cane fields and that temperatures vary with local conditions and character of plant growths within short ranges of distance.

We have not done any experimental work for the control of this disease. The F.C. 306 and D. 109 which are our most susceptible varieties are gradually giving way to the more desirabe canes, such as B.H. 10(12) and S.C. 12(4) which are much more resistant to the disease and this is solving our problem of control at this time. The future development or introduction of more valuable canes which are susceptible to the disease may force studies for the control of the disease in the future.

SUMMARY

1. The "eye spot" disease which is caused by *Helminthosporium sacchari* Butler is serious on certain varieties of sugar cane in Porto Rico.

2. It is most severe on F.C. 306 and D. 109 with H. 109 as a poor third. The Uba and P.O.J. canes are most resistant.

3. The susceptibility varies with leaf structure, the higher the fiber content the greater the resistance. However, there appears to be some slight correlation with sucrose content.

4. The young leaves are more susceptible than the old leaves; the bases and upper surfaces more susceptible than the tips and lower surfaces.

5. The spores and sporophores germinate readily in water and penetrate the leaf without regard to the stomata. The greatest mycelial growth is in the parenchyma tissues. The spores are borne more abundantly on the lower than on the upper surface of the leaf.

6. The disease is most severe during the cool, wet months of the

year. Temperature appears to be the most important environmental factor.

7. The most satisfactory control for Porto Rico at his time consists in the use of resistant varieties.

The writer wishes to express his thanks to the Hon. C. E. Chardón, Commissioner of Agriculture of Porto Rico; Mr. Rafael Menéndez, Director of the Insular Experiment Station at the time the work was started; Mr. F. A. López Domínguez, present Director of the Insular Experiment Station; Dr. O. L. Fassig of the U. S. Weather Bureau in San Juan; Mr. R. A. Veve of the Fajardo Sugar Company; Mr. Pedro Olivencia of the Cambalache Sugar Company and many others for their assistance in this work.

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EXPLANATION OF PLATES

Fig. 1.—Spores of *Helminthosporium sacchari*, showing a variety of sizes and variation.

Fig. 2.—Sporophores of *H. sacchari*, showing variations.

Fig. 3.—Sporophore and spore.

Fig. 4.—Germination of spores.

Fig. 5.—Germination of sporophore.

Fig. 6.—A spore germinating on a glass slide.

Fig. 7.—Germinating spores on leaf of sugar cane. No discolorations.

Figs. 8 *a* and *b*.—Germinating sporophores on cane leaves. *a* shows the first trace of the formation of a spot. In *b* shows the dotted line indicates the size of the spot which lies between two fibrovascular bundles.

Fig. 9.—A diagram of the lower margin of the leaf showing mycelium masses on the surface and also next to the fibro-vascular bundle. (Cross section.)

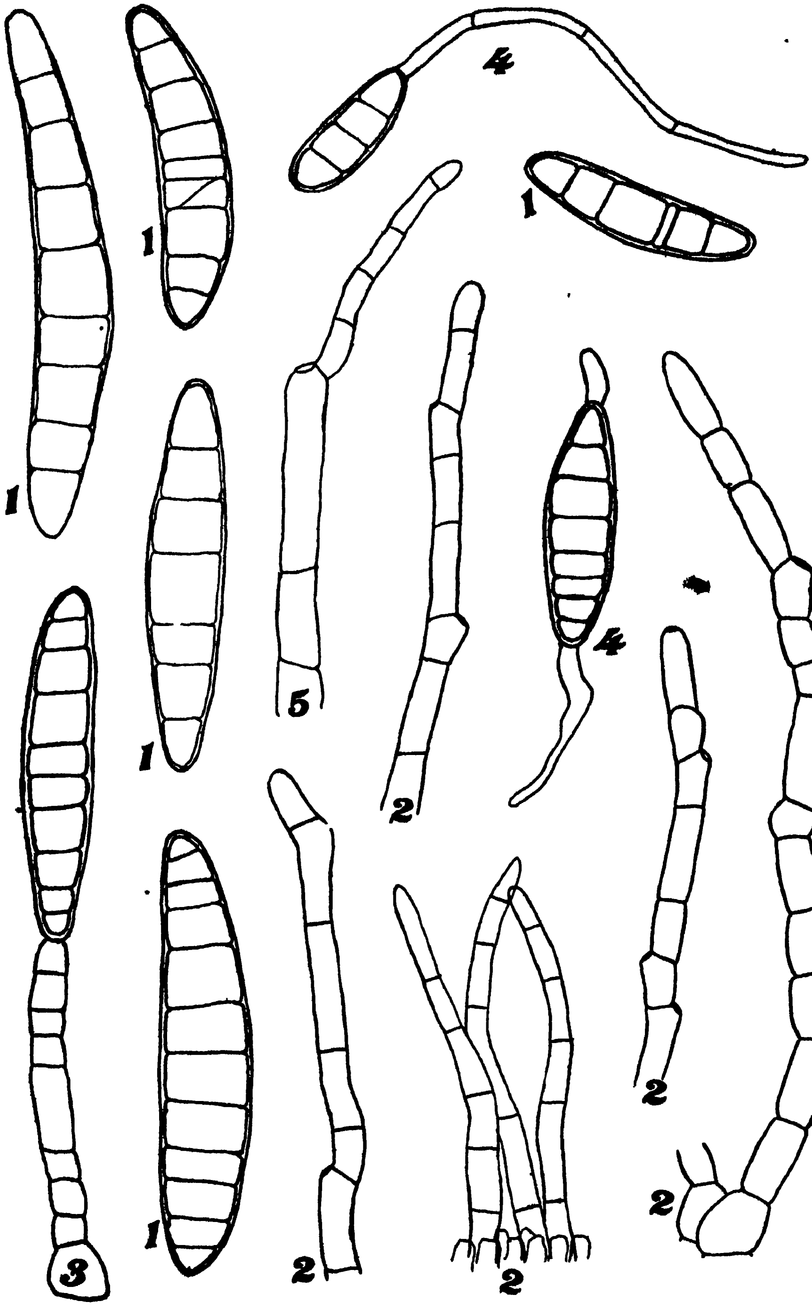
Fig. 10.—A germination spore on a leaf. One branch of the germ tube has penetrated the leaf and a spot is forming.

Fig. 11.—Showing the massing of the fungus near the lower surface of the leaf, the breaking through the epidermis, the growth on the surface and the formation of the sporophores. (See fig. 9).

Fig. 12.—The inter and intra-cellular growth of the mycellium.

Figs. 13–15.—The growth of the fungus in the cells. The large circles in 14 and 15 are tracheary tubes.

PLATE I



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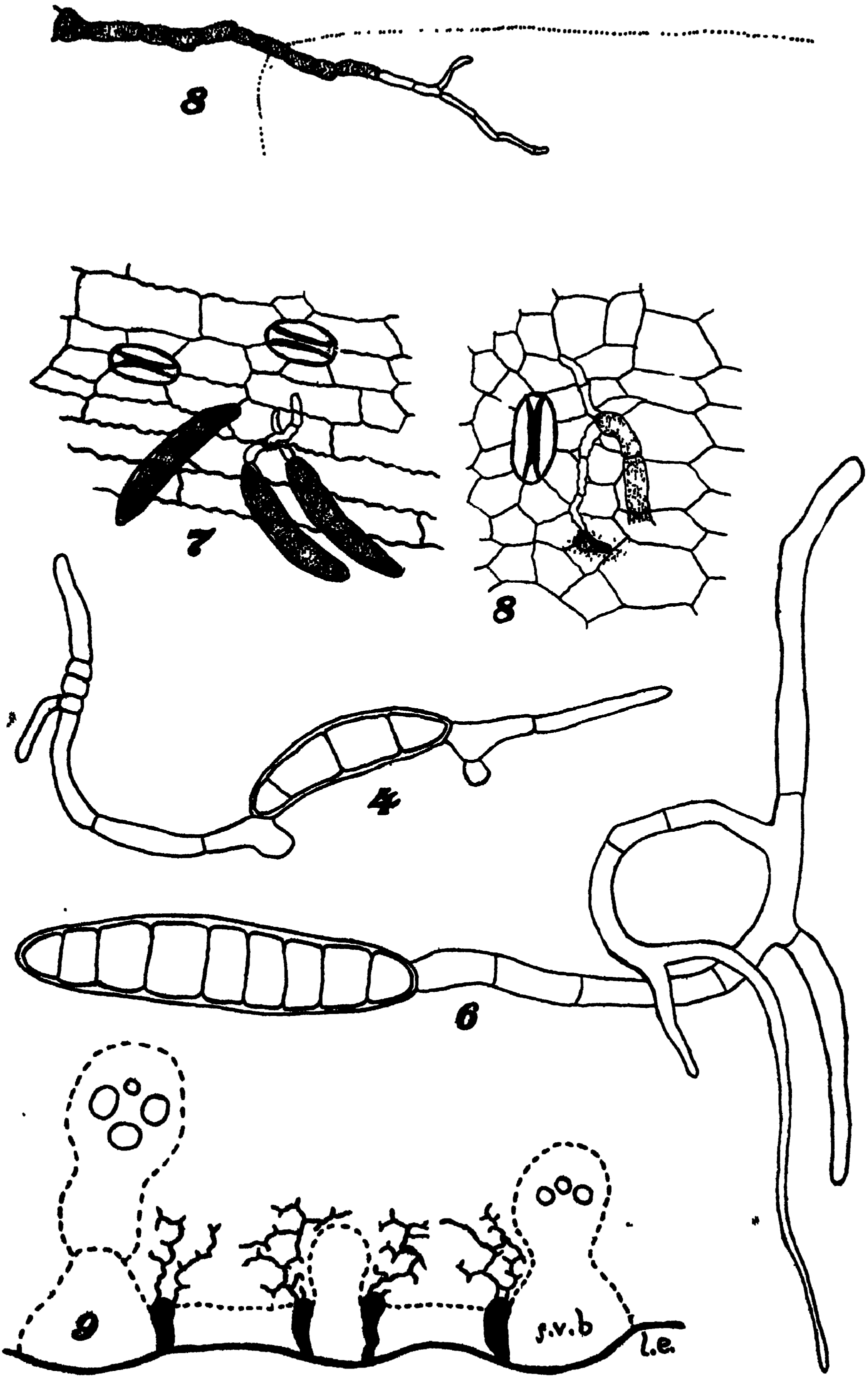

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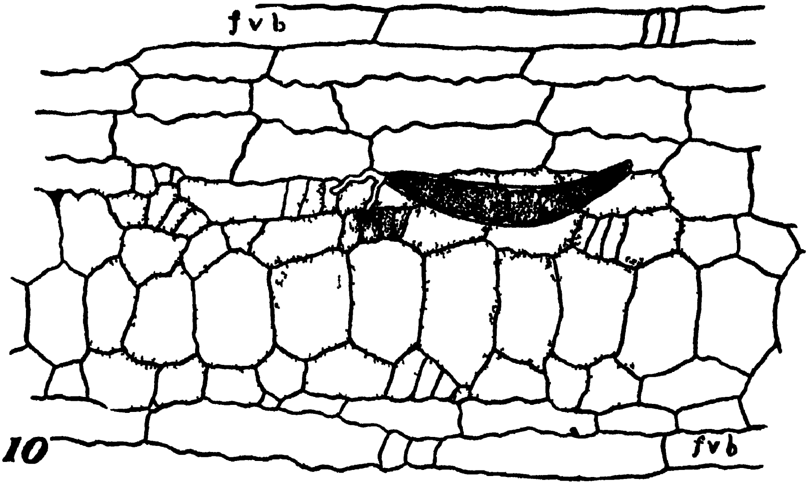

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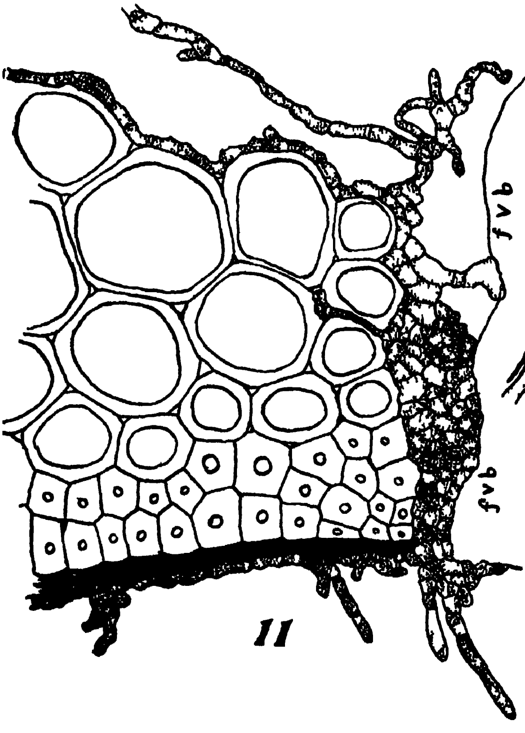

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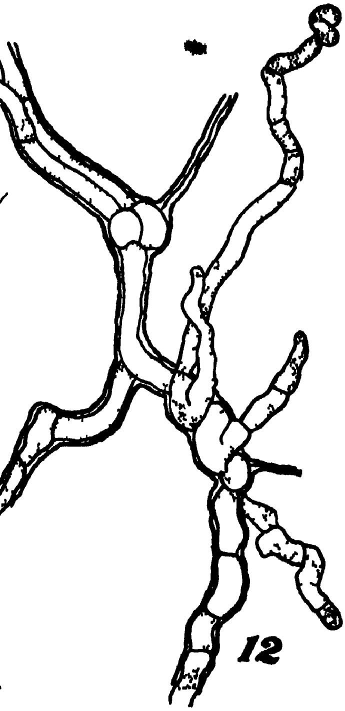

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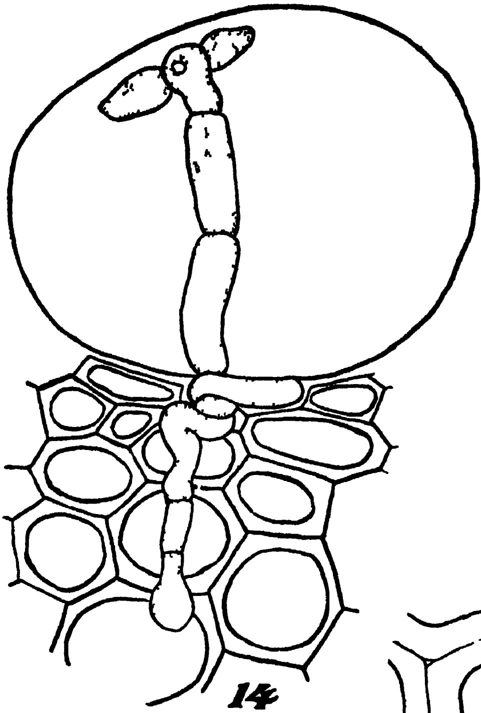
PLATE IV



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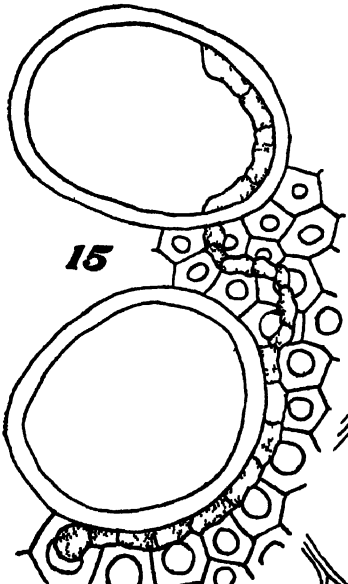

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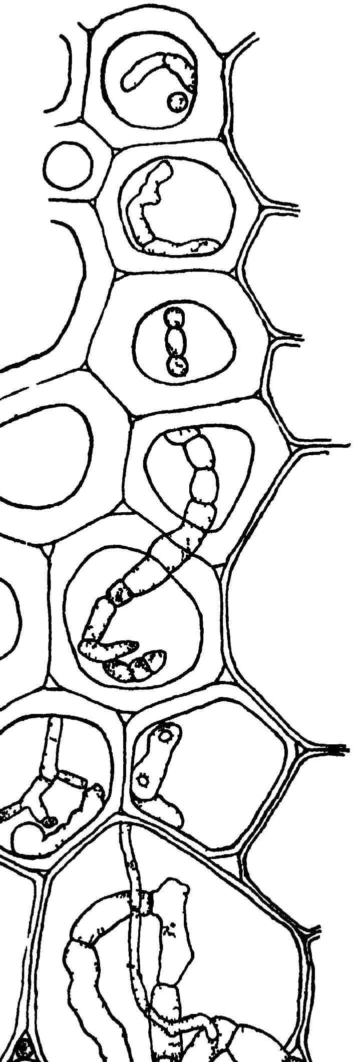

13

THE EFFECT OF MOSAIC ON THE CONTENT OF THE PLANT CELL

MELVILLE T. COOK, Chief of the Division of Plant Pathology

This paper is a report on a continuation of the studies on the cytology of mosaic plants. The studies in the first paper (1) were restricted to sugar cane, but the studies discussed in this paper were extended to include tobacco for the purposes of comparison. The greater part of this paper will be devoted to the chloroplasts, but some attention will be given to the mosaic patterns on the leaves and to other points.

The writer has already called attention to certain differences in the cells from old and young leaves of a cane plant infected with mosaic (1). It will be readily seen that the outside leaves of a sugar-cane plant are not only older than the inside leaves but that they have been subjected to the influence of sunlight and other external agencies for a much longer time; and it is well known that the older leaves of sugar cane and tobacco plants which are infected with mosaic, tend to lose their chlorotic character and become green after long exposure to sunlight.

In making these studies two plants of the same variety and age, one apparently healthy and the other infected with mosaic, were selected. Small pieces of tissue from corresponding parts of corresponding leaves were killed and fixed in weak Flemming solution, embedded in paraffine and stained by the triple-stain method. In the case of the diseased plant, the pieces were cut from both chlorotic and green areas and kept separate. This work was repeated several times but the drawings were made from two cane and two tobacco plants. In some cases plants with as many as thirteen leaves were selected while in other cases plants with as few as five leaves were selected. Sections were also made from the inner rolled leaves of the cane which had not been exposed to the direct action of the sun and in which it was impossible to distinguish the chlorotic areas.

Sugar cane and tobacco were selected for this work partly because they are important crops in Porto Rico and partly because they are so widely separated in the plant kingdom; one being monocotyledonous and the other dicotyledonous. In the sugar cane the leaves are rolled so that the young leaves are protected from the sunlight by the old leaves for a long time, while in the case of the tobacco the leaves are exposed to the direct action of the sun when very young. This is a very important point in making the comparison because of the fact that the sunlight appears to have some effect on the chloroplasts of the chlorotic cells.

Before entering into the discussion of the effect of mosaic on the contents of the cell we will briefly review a few of the well-known facts concerning the effects of mosaic on the plants. It is well known that when plants are severely infected with mosaic, they are usually dwarfed; that the leaves of mosaic tobacco plants are smaller than leaves of normal plants; that in the case of many species, the chlorotic areas of leaves of mosaic plants are slightly thinner than the leaves of healthy plants; in the case of tobacco and many other plants there is a decided modification of the leaf tissues of mosaic plants in that the palisade is replaced by mesophyll and that the mesophyll in general becomes more compact than the mesophyll of an apparently healthy leaf. The meager statements concerning cell contents are indefinite and contradictory. Thus far the writer has been unable to detect any differences between the tissues from green areas of mosaic plants and the tissues from apparently healthy plants. Therefore, for the sake of brevity, we will always refer to the green or normal in comparison with the chlorotic or diseased areas.

In general it may be said that the action of sunlight on diseased plants tends to reduce the symptoms of the disease so far as color is concerned. This has been noted by the other workers and the writer has made a careful study of this point on the two plants under consideration. In both cases leaves that are very chlorotic when young tend to become green with age. In fact this is so pronounced that in some cases it is almost impossible to select chlorotic areas in old leaves with any degrees of certainty. It is also true that the sunlight or some other factor tends to bring the choroplasts of cells in chlorotic areas to normal in appearance.

These studies have shown that in the chlorotic areas in leaves of sugar cane, the most striking cytological characters are the reduction of the chloroplasts in size and number, usually accompanied by an enlargement and deformity of the nuclei and occasionally by the presence of intra-cellular bodies. In the case of tobacco the chloroplasts respond to the disease the same as in the sugar cane but there is no such marked modification of the nuclei. However, the intra-cellular bodies are very frequent and readily detected.

The young leaves of the sugar cane before unrolling are uniformly white or nearly so, and it is impossible to say which areas are to become green and which are to remain white or chlorotic until they have been exposed to the light; but a cytological study of these leaves show that certain groups of cells already possess certain characters of chlorotic areas of later periods. The young leaves of diseased tobacco are usually almost white but develope the mosaic pattern with age. A cytological study of these young leaves reveals groups of cells which show the effects of the disease before the leaves show the mosaic pattern.

Kunkel (6) as a result of his studies on sugar cane says:

> "The pattern shown by the leaves of most plants afflicted with mosaic is already present when the young leaves unfold and begin to turn green. For this reason it is in most cases not possible to determine how the chlorotic areas arise. In the case of sugar cane, however, the pattern shown by old leaves is usually not present on young ones and it is, therefore, possible to observe the chlorotic areas in process of formation. It has been observed that they begin as small spots scattered about over the leaf. The spots grow and finally include much tissue that was at first a normal green color. In their growth, the spots that happen to be close together coalesce and form chlorotic areas of various sizes and shapes. While the areas resulting from the fusion of two or more spots are quite irregular in shape, the spots themselves show considerable regularity."

Further on in this paper he says:

> "While a part of this enlargement was due to the growth of the leaf, most of it resulted from the spread of chlorosis in the normal green tissues bordering the spots."

Our studies indicate that the chlorotic areas in sugar cane are quite definitely determined before the formation of chlorophyll which enables the observer to detect them with the unaided eye. The areas which are to be chlorotic can certainly be detected in properly prepared microscope sections. These areas increase in size with the growth of the leaves, but so far as the writer has been able to determine they do not encroach on the surrounding green tissues and do not coalesce. The increase in size appears to be by cell division and growth and not by infection of surounding cells.

Kunkel also states that—

> "It has been observed, however, that new spots sometimes arise in the normal green tissues as leaves unroll from the spindle."

My study of sections show that groups of cells so small that they cannot be seen with the unaided eye frequently occur in green areas of young leaves. It is very probable that groups of this kind enlarge with the growth of the leaf and give the appearance of new spots.

Kunkel also says—

> "It has frequently been observed that the central areas of some spots are a normal green color and that only the borders are markedly chlorotic. Sometimes a small elongated chlorotic spot lies in the center of the green area."

The writer has observed the same character and has also been able to trace them by means of sections back into young leaves.

It will be readily seen from this discussion that the patterns cannot be detected on the young leaves previous to the formation of chlorophyll Exposure to sunlight intensifies the patterns for a time but eventually the chlorotic areas undergo a slow formation of chlorophyll until it is practically impossible to detect the patterns in the very old leaves. This has been observed by Kunkel who says:

> "In other varieties, the light, greenish areas, instead of deteriorating as the leaf ages, have a tendency to recover. They may become so green that it is difficult to distinguish them from areas of normal green color."

The presence of the great masses of trichomes makes it very difficult to study the early stages of the mosaic patterns on the tobacco. However, the writer is inclined to believe that they develope in the same manner as in the sugar cane; and it is certainly true that their later history is the same.

CYTOLOGICAL CHARACTER

The references to the chloroplasts in the early literature are brief and unimportant. Koning **(5)**, in his study of tobacco mosaic (1899) found that chloroplasts were disorganized. Ivanowski **(4)**, in his studies on tobacco mosaic (1903) reports that the chloroplasts in the chlorotic cells were yellowish and scarcely reacted to the starch test but later they contained as much starch as they could hold. Westerdyk **(9)** made a study of the tomato mosaic and reports (1910) that the chloroplasts of the chlorotic areas were slightly smaller. Melchers **(8)**, made a study of the mosaic of tomatoes and reported (1913), that no difference was detected in the number and size of the chloroplasts in the yellow and green areas. Matz **(7)**, made a study of the mosaic disease of the sugar cane and writes (1922) as follows:

> "In the diseased tissues the chloroplasts are few and are evidently misshaped and broken up. In stained sections they look like mere ink spots, one or two in a cell. This destruction of chloroplasts is a symptom of sugar-cane mosaic and it fixes the seat of the disease more definitely. Apparently the cell walls and other cell contents are not affected, but the chloroplasts are gradually destroyed."

> 'It was seen that the breaking up of the chloroplasts begins with a reduction in their size. The chloroplasts in the healthy or green parts of the same leaf were normal in their size and numbers, while in the discolored or pale-green striped chloroplasts in all stages of reduction were noted.''

Dickson (2), made a study of a considerable number of species of plants infected with mosaic and reported (1922) that the cells of the chlorotic areas contained less chlorophyll because of the fewer chloroplasts, less chlorophyll per plastid, the beaking down of the plastids or the general coalescence and degeneration of the plastids.

As a result of cytological studies on the mosaic of sugar cane, the writer of this paper wrote (1) as follows:

> ''A study of the cells of these leaves shows that the chloroplasts are more numerous in the dark-green than in the light areas. Therefore, it appears that in the case of the light-green areas the formation of the chloroplasts is inhibited but that with the exposure to sunlight this inhibition is gradually overcome.''

* * * * * * *

> ''The chloroplasts in the white or yellow areas were fewer in number and smaller than in the green areas.''

* * * * * * *

> ''The small chloroplasts of the mosaic cells are usually spoken of as having undergone a process of degeneration. The writer has studied the chloroplasts in the very young unrolled leaves and is satisfied that these chloroplasts are undeveloped rather than disintegrated. They have never reached normal development. Furthermore a study in a series of leaves from those just unrolling to the outermost on a plant shows that the chloroplasts of both normal and mosaic cells increase in size after being exposed to the light. These changes which are apparently due to age or light are so pronounced that there is very little difference in size of the chloroplasts in a leaf of the same age from a healthy plant. The writer is very doubtful if disintegration ever occurs in the case of primary infection (*i.e.*, infection from the seed).''

Since the writing of the above paper, Eckerson (3), published the results of her studies on tomato mosaic in which she describes a flagellate organism found in the chloroplasts. In this paper she repeatedly refers to the ''dissolution'' and ''liquification'' of the chloroplasts.

In the light of these recent studies on mosaic it seemed advisable to extend my own studies; to repeat the studies on the sugar cane and to make a comparison with the tobacco. These two species were available in great abundance and since they are widely separated in the plant kingdom they appeared to be especially satisfactory for this purpose.

The plants for these studies were carefully selected. Healthy and diseased plants of sugar cane or tobacco of the same variety, age and approximately of the same size having been selected, the studies were made on corresponding tissues under as nearly the same conditions as possible. The plants were grown within less than 100 yards of the laboratory which facilitated the immediate study of fresh tissues and the immediate killing and fixing of tissues for sectioning.

In the study of the sugar cane it must be remembered that there are two types of parenchyma cells in the leaves: (1) The single layer of cells which form a sheath around the fibro-vascular bundle and which we will refer to as the sheathing cells are very regular in size and shape. They are tubular, more or less cylindrical and placed lengthwise with the fibo-vascular bundle; and (2) the ordinary mesophyll cells which are very irregular in both size and form.

In the series of cross sections of leaves of healthy plants from the inside outward (Figs. 1 *a* to 1 *e*), beginning with leaves that are of an age corresponding to diseased plants in which the chlorotic areas can be detected without error, it will be readily seen that there is no very great variation in character of cells, nuclei or chloroplasts. Cross sections from corresponding parts of diseased plants (Figs. 2 *a* to 2 *e*) show that the nuclei are more or less enlarged or irregular in form and that there is a tendency for the chloroplasts to be slightly more numerous and larger in the outer leaves which are older and have had a longer exposure to light than in the inner leaves.

These characters are much more prominent in longitudinal sections than in cross sections as will be readily seen by a study of the figures 4–6 which were drawn from sections made from the same leaves as those from which figures 1 and 2 were drawn. The nuclei and chloroplasts in the sheathing cells in leaves from the inside of a healthy plant are practically the same (Figs 3 *a*–3 *e*). An examination of sections from corresponding cells of a diseased plant (Figs. 4 *a*–4 *e*) show that the nuclei in the sheathing cells are slightly larger than in the corresponding cells of a healthy plant. Also the chloroplasts in the sheathing cells of the inner leaf are few and small but increase in size and number from the inner to the outer leaves. The same facts are brought out by a study of the nuclei and chloroplasts of the ordinary parenchyma cells. The nuclei and choroplasts are very uniform in cells of leaves of a healthy plant (Figs. 5 *a*–5*e*) regardless of age; but in corresponding cells of the diseased plants the nuclei are very generally larger and irregular in form, while the chloroplasts tend to increase in number and size from inner to outer leaves. A considerable number of plants were used in making these studies, but all the drawings 1 to 6 were made from two plants.

A more detailed study of the nuclei and chloroplasts of these same cells emphasizes the points previously referred to. The nuclei (Fig.

7) of the sheathing cells of a healthy plant are very regular and uniform in size while those from the sheathing cells of a diseased plant (Fig. 8, *a* to *e*) tend to be slightly larger and occasionally elongated. In the ordinary mesophyll cells of a healthy plant the nuclei (Fig. 9) are quite regular as compared with the nuclei (Fig. 10, *a* to *e*) from the corresponding cells of a diseased plant; many (but not all) of which are very irregular in size and shape.

The chloroplasts in the sheathing cells (Fig. 11) of a healthy plant are large and the markings well defined as compared with the chloroplasts (Fig. 12, *a* to *e*) from the corresponding cells of a diseased plant which are small and with poorly defined markings. The chloroplasts (Fig. 13) in the ordinary mesophyll cells of a healthy plant are large and regular as compared with the chloroplasts (Fig. 14, *a* to *e*) from the corresponding cells of a diseased plant. However, as previously stated, the chloroplasts in the chlorotic areas in the older leaves of a diseased plant are very nearly or quite normal in appearance. No disintegration of the chloroplasts were observed in any case except in the very old leaves which were decaying from old age or in tissues which were decaying as a result of the attacks of fungi.

The above studies were followed by the study of cross sections of leaves well within the spiral which had not been exposed to the direct light of the sun. These leaves were white and there was no indication of the formation of chlorophyll (Figs. 15–16). By carefully selecting severely diseased plants it was possible to find many groups of cells with enlarged or deformed nuclei. It appears that these groups of cells are destined to grow into the chlorotic areas. These cells no doubt increase in size and divide but the writer is very doubtful if the surrounding cells become chlorotic. It will be readily seen that it is difficult to secure evidence for or against this opinion but the study of spots on leaves that were showing the green failed to show any evidence that the spots were increasing in size except with the growth of the leaf. The writer is in disagreement with Kunkel on this point.

Groups of apparently normal cells so small that they cannot be detected by the unaided eye can be found within groups of diseased cells of the chlorotic areas. This no doubt accounts for the small island of green tissue surrounded by chlorotic tissue as observed by Kunkel and the writer. Likewise, groups of abnormal cells so small that they cannot be detected by the unaided eye are frequently found in sections made from apparently normal tissue.

Similar studies on healthy and diseased plants of tobacco do not show any great variation in the nuclei, but the history of the chloroplasts is exactly the same as in the sugar cane. The chloroplasts in the mesophyll cells of a healthy plant are large and regular (Fig 18–19) as compared with the chloroplasts from corresponding cells of the chlorotic areas of a diseased plants (Figs. 20 and 22) In the study of a series of sections from young to old leaves of a diseased plant, there is a pronounced tendency for the cloroplasts to become normal in appearance with age and exposure to light and possibly other agencies.

The tendency of leaves of diseased plants of both sugar cane and tobacco to become more or less uniformly green with age and exposure to sun light is no doubt due to tendency of the chloroplasts in the cells of the chlorotic areas to increase in number and size. This could not possibly be the case if the chloroplasts were undergoing disintegration.

The intra-cellular bodies previously described by Kunkel are rare in sugar cane but are quite common in diseased tobacco (Figs. 23–25). They appear to be the same as the bodies described and figured by Iwanowsky in his studies on mosaic of tobacco. The writer is inclined to believe these bodies to be the result, rather than the cause of the disease although it is difficult to point out any very definite reasons for this opinion. Circles (Fig. 23) and some other points noted by Iwanowsky can be found occasionally in both diseased tobacco and diseased sugar cane but there does not appear to be any good reason for believing that they have anything to do with the disease. Small moving bodies are very abundant in the cells of mosaic tobacco plants but these same bodies can be found in healthy plants, although they are not so abundant. These same or similar bodies can also be found in diseased and in healthy sugar cane but are much less abundant than in tobacco. The writer failed to find any flagellate bodies attacking the chloroplasts as were described by Eckerson as attacking chloroplasts of the tomato. However, this phase of the question is worthy of further investigation.

SUMMARY

1. The mosaic pattern is indistinct on the very young leaves, becomes prominent with the growth of the leaves; then becomes less distinct with age.

2. The chlorotic areas tend to become green with age. This is probably due to the action of the sunlight on the chloroplasts.

3. The chloroplasts in the chlorotic areas are fewer in number and smaller than in the green areas. There is no evidence of disintegration.

4. The tendency of the chlorotic areas to become green with age is due to increase in number and size of the chloroplasts.

5. The chlorotic areas can be detected by cytological studies before the unfolding of the leaves.

6. The chlorotic areas increase in size by cell division and cell growth and not by the infection of surrounding cells or by a disintegration of the chloroplasts of the surrounding cells.

7. The formation of apparently new chlorotic areas in leaves is probably due to very small infected areas which increase in size with the general growth of the cells.

8. Green areas in a chlorotic area can be detected by cytological studies before they can be detected by the unaided eye.

9. The small size and number of chloroplasts is common to both sugar cane and tobacco when infected with mosaic.

10. The nuclei of diseased cane cells are usually enlarged or deformed, but this is not true of tobacco.

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EXPLANATION OF PLATES

Figs. 1*a* to 1*e*.—Cross sections from a series of normal leaves showing sheath cells of the fibro-vascular bundles and ordinary parenchyma cells. 1*a* is the youngest and 1*e* the oldest leaves in the series. Leaves *b* and *d* omitted.

Figs. 2*a* to 2*e*.—Cross sections from a series of mosaic leaves showing sheath cells of the fibro-vascular bundles and ordinary parenchyma cells. 2*a* is the youngest and 2*e* the oldest leaves in the series. Leaves *b* and *d* omitted. Note the reduced number and size of the chloroplasts and the abnormal nuclei as compared with Fig. 1*a* to 1*e*. Note also the chloroplasts tend to become normal in appearance with age.

Figs. 3*a* to 3*e*.—Longitudinal sections of sheath cells of the fibro-vascular bundles from the same leaves as Figs. 1*a* to 1*e*.

Figs. 4*a* to 4*e*.—Longitudinal sections of sheath cells of the fibro-vascular bundles from the same leaves as Figs. 2*a* to 2*e*.

Figs. 5*a* to 5*e*.—Ordinary parenchyma cells from same leaves as Figs. 1*a* to 1*e*.

Figs. 6*a* to 6*e*.—Ordinary parenchyma cells from same leaves as Figs. 2*a* to 2*e*.

Fig. 7.—Four nuclei from sheath cells of normal leaves. From same leaves as Figs. 1*a* to 1*e*.

Figs. 8*a* to 8*e*.—Four nuclei from sheath cells of mosaic leaves. From same leaves as Figs. 2*a* to 2*e*.

Fig. 9.—These nuclei from ordinary parenchyma cells or normal leaves. From same leaves as Figs. 1*a* to 1*e*.

Fig. 10.—Eight nuclei from ordinary parenchyma cells of mosaic leaves. From same leaves as Figs. 2*a* to 2*e*.

Fig. 11.—Chloroplasts from sheath cells of normal leaves. Same as Figs. 1 and 3.

Figs. 12*a* to 12*e*.—Chloroplasts from sheath cells of normal leaves. Same as Figs. 2 and 4.—(*a* inside leaf. *e* outside leaf.)

Fig. 13.—Chloroplasts from ordinary cells of normal leaves. Same as Figs. 1 and 5.

Figs. 14*a* to 14*e*.—Chloroplasts from ordinary cells of mosaic leaves. Same as Figs. 2 and 4. (*a* inside leaf. *e* outside leaf.)

Figs. 15–16.—Sections through leaves of mosaic plants which had not been exposed to the sun. No chlorophyll had been developed but many of the nuclei were abnormal.

Fig. 17.—Cross section of normal leaf of tobacco.

Figs. 18 and 19.—Cells from cross section of normal leaf of tobacco figured in 17.

Fig. 20.—Cross section of mosaic leaf of tobacco. Same age as 17. Note the abnormal chloroplasts.

Figs. 21 and 22.—Cells from cross section of mosaic leaf of tobacco, figured in 20. Note the abnormal chloroplasts and the intra-cellular bodies.

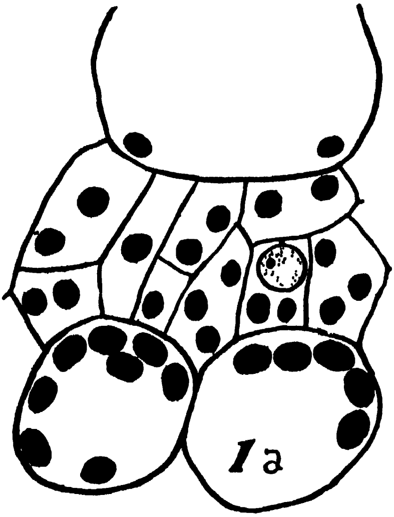
Fig. 23.—Cells from cross section of mosaic tobacco leaf, figured in 21. Note the intra-cellular body in one cell and the rings in the other.

Fig. 24.—Cell from cross section of mosaic of leaf of tobacco. Note the intra-cellular bodies and the abnormal chloroplasts.

Fig. 25.—Plant hair from mosaic tobacco. Note the intra-cellular body in the outer cell.

Fig. 26.—Nuclei and intra-cellular bodies from cross section of mosaic leaf of tobacco, figured in Fig. 20.

PLATE I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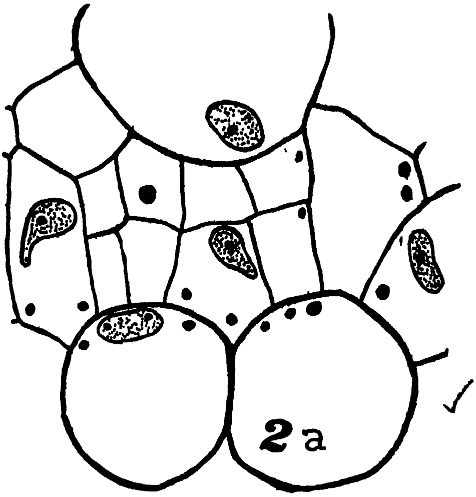
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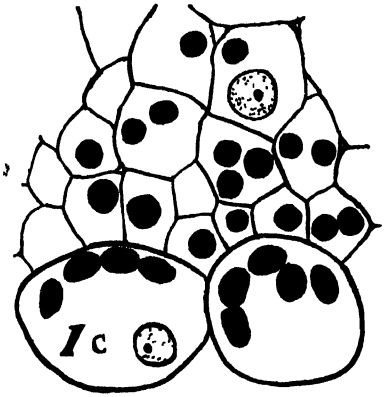
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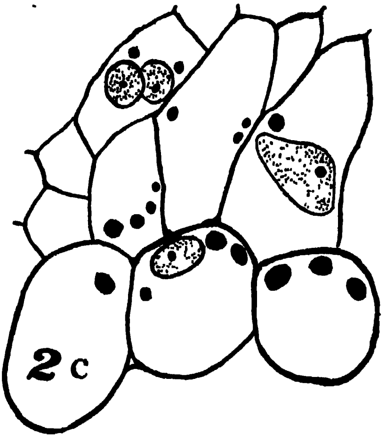
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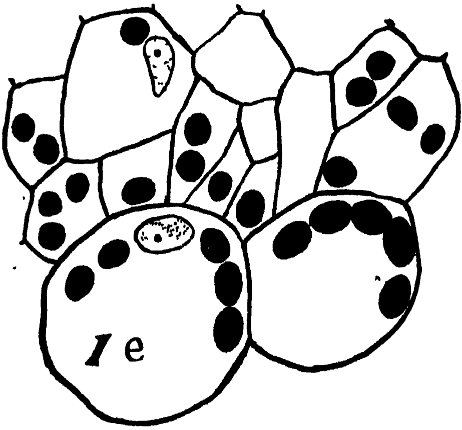
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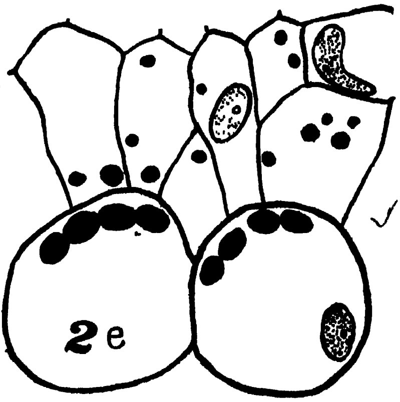
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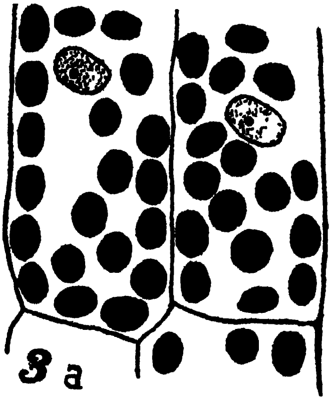
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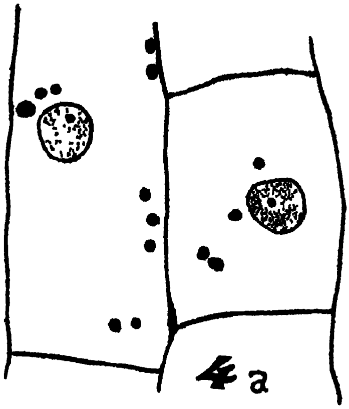
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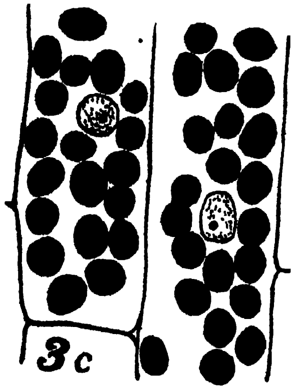
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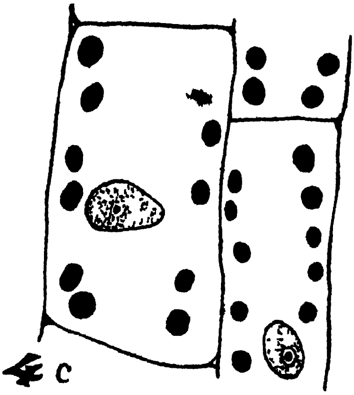
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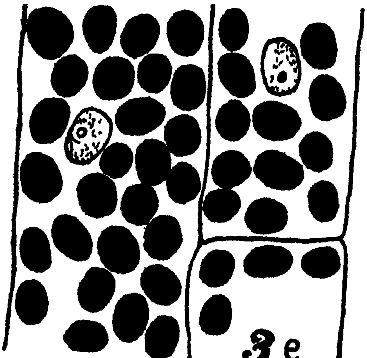
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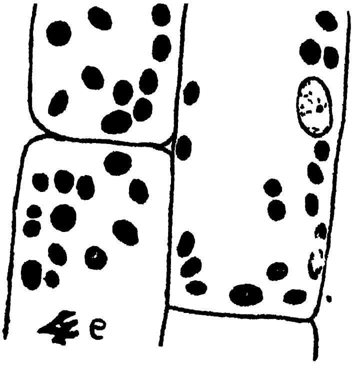
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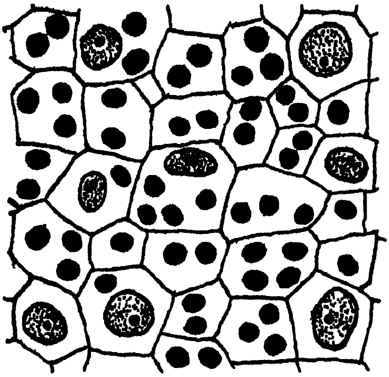

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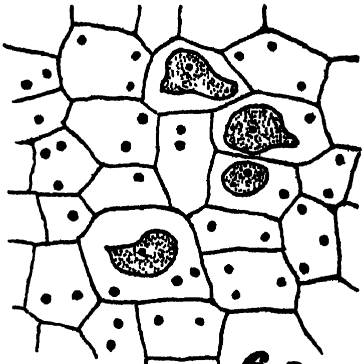

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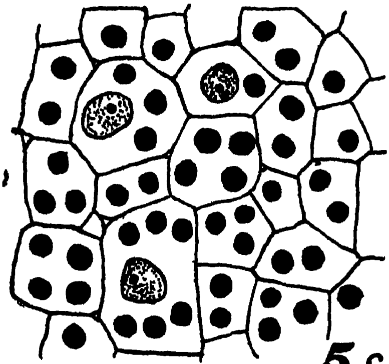

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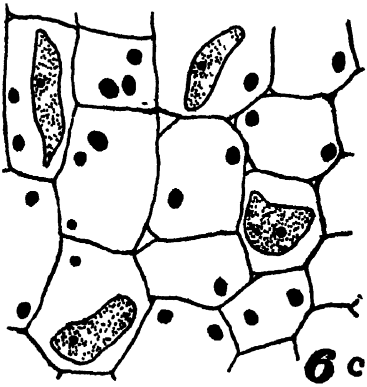

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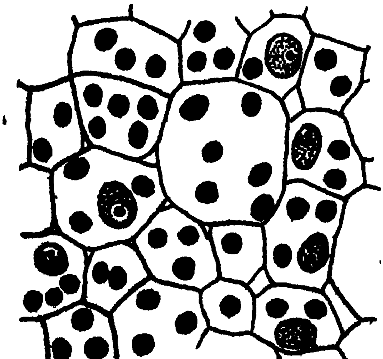

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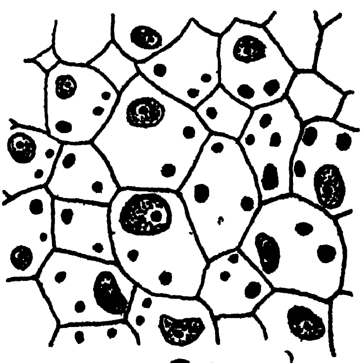

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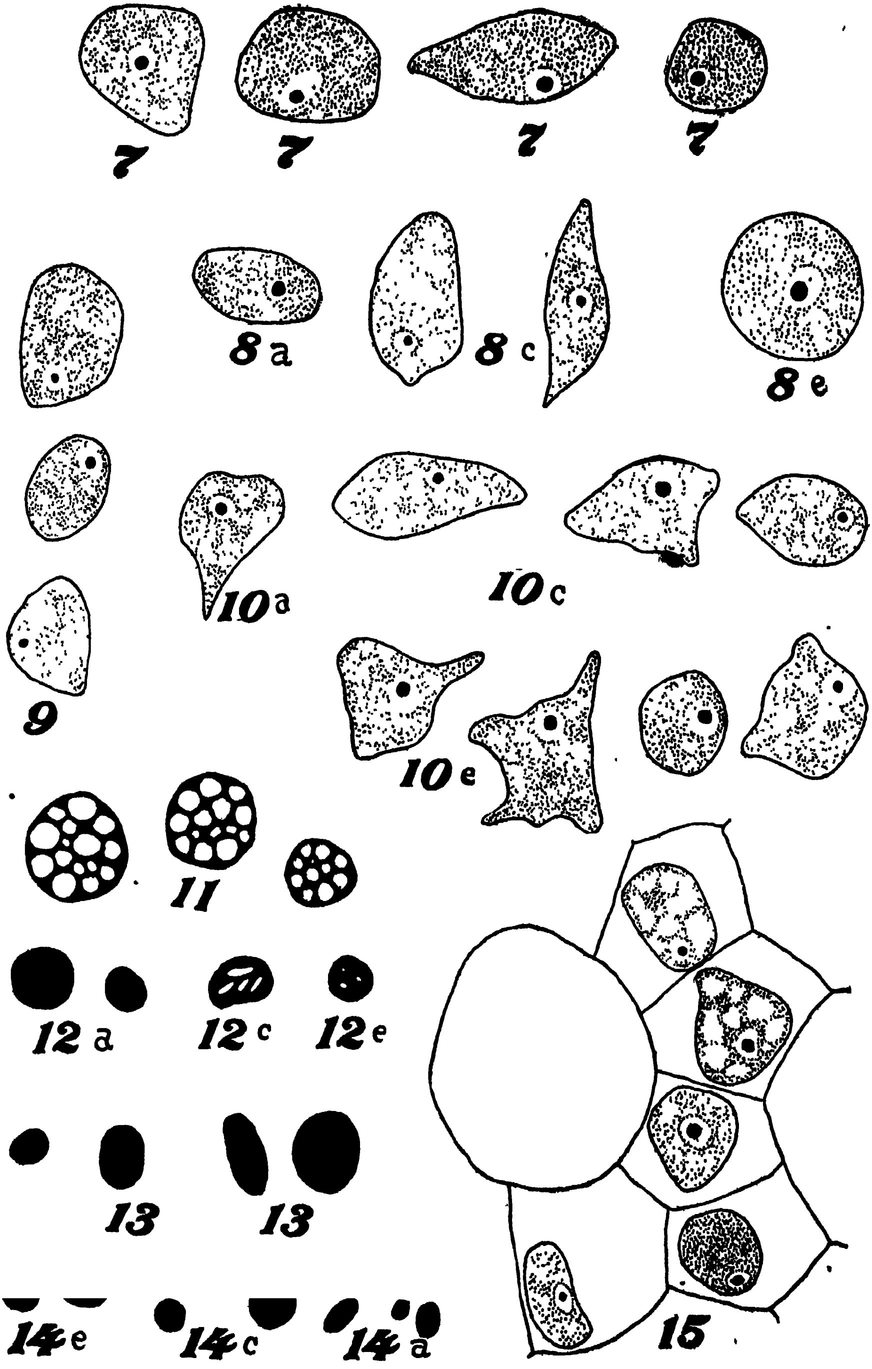

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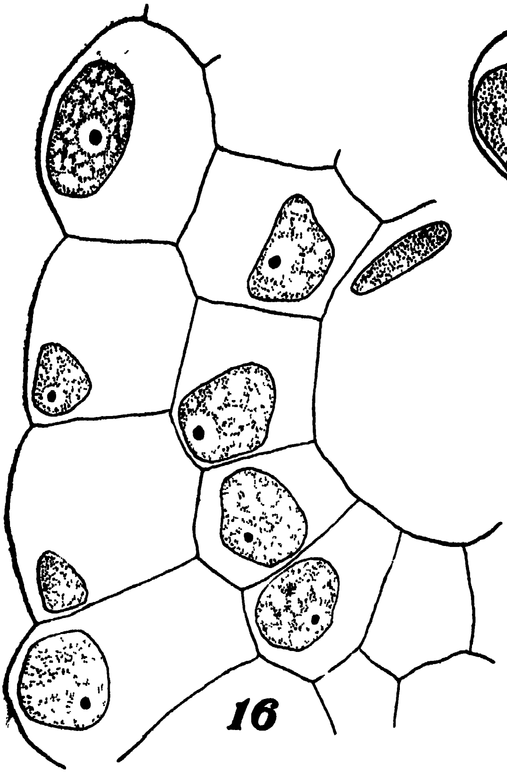
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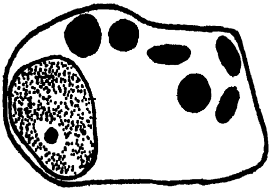
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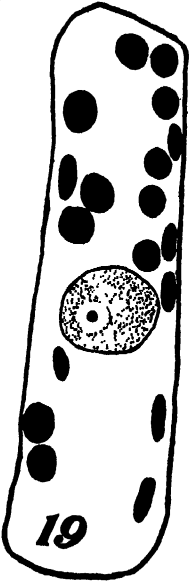
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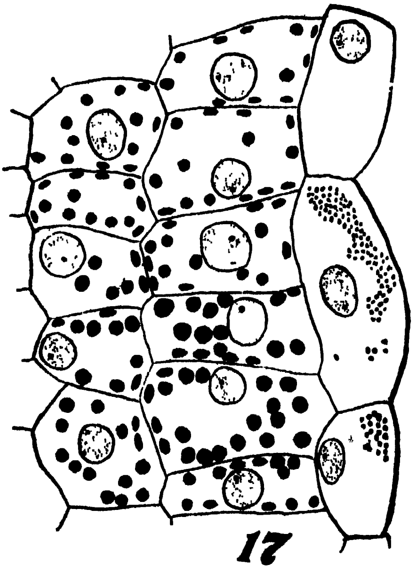
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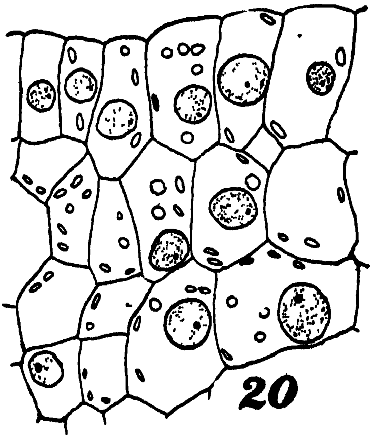
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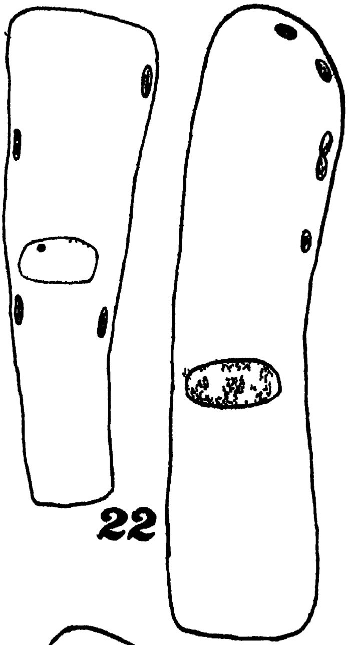
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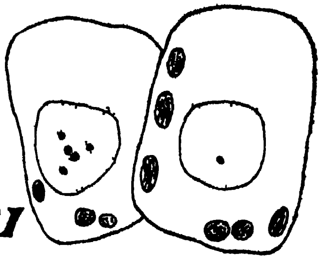
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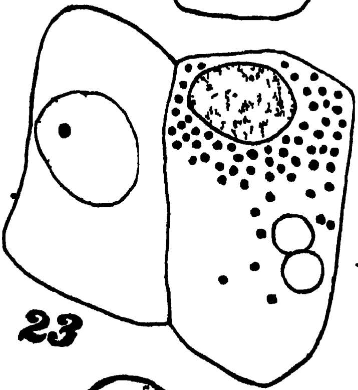
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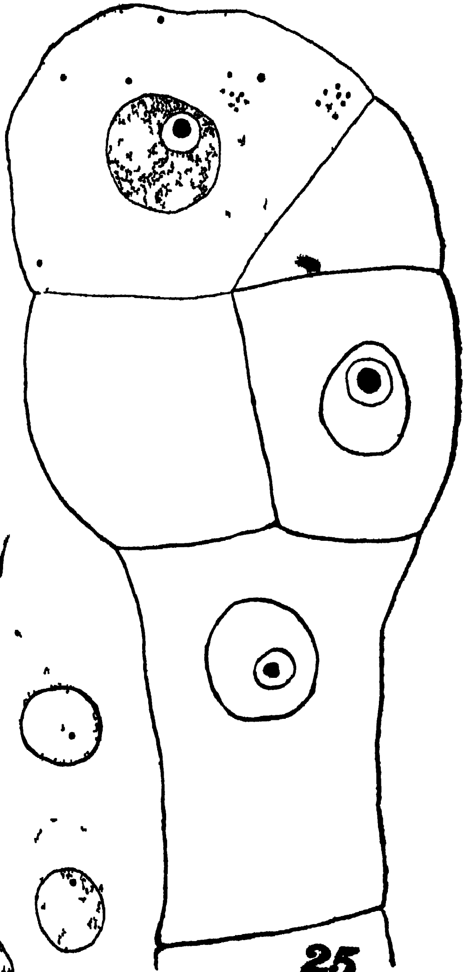
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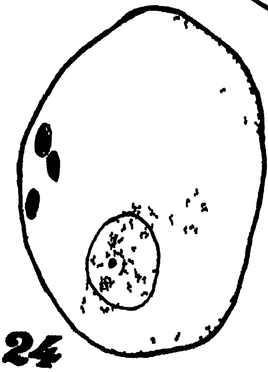
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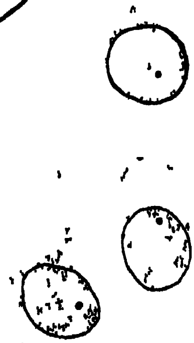
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PHOTO-SYNTHESIS OF THE SUGAR CANE MOSAIC PLANT

MELVILLE T. COOK, Chief of the Division of Plant Pathology

The symptoms of the mosaic diseases of many plants and the symptoms of plants with similar diseases such as "peach yellows" and "little peach" indicate a reduced or disturbed photo-synthesis, which usually results in a reduced growth or death or both.

References have been made in a number of papers on mosaic diseases to the amount of starch in the chlorotic cells of diseased plants but so far as the writer has been able to determine no special studies have been made on the relationship of the disease to photo-synthesis or any comparative studies on the photo-synthetic action of normal plants and those infected with mosaic. It is the purpose of this paper to give some of the accumulated data bearing on the photo-synthetic activities of some mosaic plants and the results of our own studies on the photo-synthesis of mosaic of sugar cane as compared with healthy plants.

The white, yellowish and light-green areas which are characteristic of mosaic plants indicates a reduction in amount or absence of chlorophyll, or an abnormal condition of same and most of the references in the literature indicate that this is true. Any of these conditions would necessarily interfere with the photo-synthetic activities of the plant. The limited references to this phase of the subject may be summarized as follows: In 1899 Koning (8) who was making a study of tobacco mosaic called attention in some cases to the disorganization of the chloroplasts. In 1900 Woods (12) reported that the light-colored areas of both tobacco and tomato plants infected with mosaic contained more than the normal amount of starch, which is contrary to the findings of most workers. And in 1902 (13) the same author makes this statement:

> "the disease is not primarily a disease of the chloroplasts; as Beijerinck thought, is evident from the fact that in the less pronounced cases the chloroplasts, though fewer in number, are not decreased in size or activity."

In 1903 Iwanowsky (7) reported that when the leaves of mosaic tobacco plants were young, the chloroplast in the light areas were yellowish and scarcely reacted to the starch tests, but that later the chloroplast contained a large amount of starch. This indicates that the plant passes through an abnormal condition from which it partly or completely recovers so far as the photo-synthetic processes are concerned. In the same year Bouygues (2) reported the disappearance of the cell contents in the light areas of mosaic tobacco leaves. In 1910 Westerdyk (11) reported that in the case of tomatoes, the chloroplast in the cells in the yellow areas were smaller than those in the green areas and contained very little starch. In 1913 Melchers (9) reported on tomato mosaic as follows:

> "No difference was detected in the number or size of the chloroplast in the yellow and green areas. That they were well supplied with starch was apparent."

The same author in the same year reported on potato mosaic as follows:

> "The chloroplast throughout the yellow regions in the living material were a pale yellowish-green but contained considerable starch."

In 1918 Artschwager (1) reported an accumulation of starch in the leaves of leaf-roll potatoes. In this same year True and Hawkins (10) conducted chemical studies on spinach which indicated that both starch and sugar content were greater in diseased than healthy plants. Their results are summarized as follows:

> "It appears that in spinach-blight the process of carbo-hydrate manufacture is not inhibited although it may be retarded."

These studies were chemical and not cytological and were made on diseased plants as compared with healthy plants; but not on chlorotic areas as compared with normal areas. It is doubtful if these results should be placed in the same category as the others which are referred to in this paper. In 1921 the author (3) of this paper reported the results of studies on "peach yellows" and "little peach". These studies indicated that the translocation of starch was partly or completely inhibited in the diseased trees. The accumulation of starch no doubt explains the thick, leathery texture of old leaves infected with either of these diseases. In 1922 Dickson (6) reported that in tobacco-mosaic leaves there was a reduction in the number of chloroplasts which in the case of the palisade cells were irregularly arranged in the lower half of the cells. In 1925 the author of this paper expressed the opinion as a result of the study of the histology and cytology of mosaic sugar cane (4) that the chloroplasts did not undergo disintegration but that their development was inhibited. In 1927 the writer of this paper reaffirmed (5) his opinion that the chloroplasts of the chlorotic areas did not undergo degeneration as a result of the disease but that they were undeveloped from the beginning and tended to become normal in appearance with age and exposure to sunlight.

A careful review of the data presented in the papers bearing on this subject, show some differences of opinion concerning the contents of the cells, especially with reference to the presence and character of the chloroplasts, but the paper on "peach yellows" and "little peach" by the writer (3) of this paper is the only one that the author has been able to find in which there is any effort to correlate the presence or absence of carbohydrates with the photosynthetic activity of the plant.

During the past three years the writer of this paper has been making studies on the photo-synthetic activity of sugar-cane plants infected with mosaic as compared with normal plants. These studies were restricted to the microscopic examination of plants collected between 5 and 6 A. M. and between 2 and 3 P. M. The tissues were treated in various ways to bring out the desired information. The plants for study were grown within 100 feet of the laboratory. In some cases the studies were made immediately on free-hand sections while in other cases the sections were prepared by longer processes.

These studies showed that the normal plants and the green areas of the diseased plants performed their proto-synthesis in the normal manner and showed a large amount of starch in the afternoon and very little in the morning, while the white and light green or yellowish areas showed a small amount of starch in the afternoon and practically none in the early morning (Figs. 1 to 4) It was very evident that the starch-forming power of the mosaic cane was reduced in proportion to the amount of infection while the power of translocation was practically unimpaired This is the reverse to the findings of the writer in the case of the "peach yellows" and "little peach" in which the cells of the diseased leaves are filled with starch but in which the translocation is greatly reduced or completely inhibited. These studies indicate that we may have two types of disease; the one generally represented by the various mosaics in which the photo-synthetic activities are greatly reduced. The second which is represented by "peach yellow" and "little peach" in which starch is formed in the leaves but not transported to other parts of the plant, the result being that the leaves become hard and leathery. The accumulation of starch in the leaves of "leaf roll" potatoes which has been referred to by Artschwager and the leather texture of the leaves of such plants, may indicate that the "leaf roll" of potatoes should be classed with the "peach yellows" and "little peach". These studies also showed that the old leaves of sugar cane infected with mosaic produced more starch than the young leaves of the same plants. This is no doubt due to the fact that the chloroplasts in chlorotic areas of mosaic plants tend to increase in size and number with the age of the leaf as indicated in another paper by the author (5).

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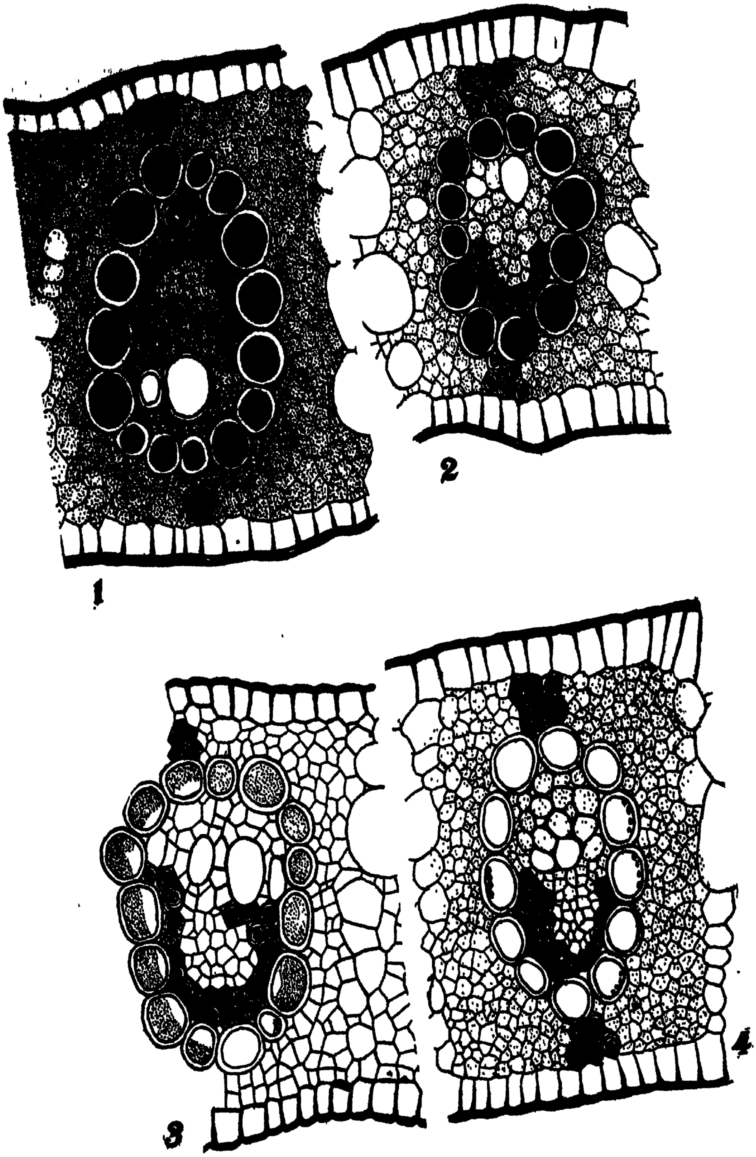
EXPLANATION OF PLATES

Fig. 1.—Cross section of leaf of normal plant at 3:00 P. M.
Fig. 2.—Cross section of leaf of mosaic plant at 3:00 P. M.
Fig. 3.—Cross section of leaf of normal plant at 6:00 A. M.
Fig. 4.—Cross section of leaf of mosaic plant at 6:00 A. M.

PLATE I



THE UNROLLING OF THE LEAVES OF SUGAR CANE

MELVILLE T. COOK, Chief of the Division of Plant Pathology

The unrolling of the leaves of monocotyledonous plants, such as sugar cane and corn is such a common phenomenon that it appears to have been overlooked by students and writers. While pursuing studies on the mosaic disease of the sugar cane the attention of the writer was attracted to the anatomical structures involved in the unrolling of the leaf. Before discussing this point it will be necessary to call attention to the structure of the mature leaf. In the mature leaf we find three sizes of fibro-vascular bundles. The largest constitute the parallel veins which are so well defined in the leaf as to be visible to the naked eye and extend from epidermis to epidermis. The other two sizes are arranged alternately and the number between any two of the veins is variable, but fairly constant for each variety. The medium-sized bundles are always in contact with the outer or lower epidermis and may or may not be in contact with the upper or inner epidermis. The space between the upper and lower epidermis which is not taken up by the fibro-vascular is filled with parenchyma cells of many sizes, the smaller ones being next to the bundles and to the lower epidermis which are in contact with the larger bundles coming in contact with the upper epidermis. The medium-sized cells are between the bundles. The largest cells are in contact with or very near the upper epidermis. In some cases they supplant the ordinary type of epidermis and in fact are large epidermis cells which extend far into the tissues of the leaf and have a thin cuticle on the exposed surface. Therefore, there is much more parenchyma near the upper than near the lower epidermis and the large cells are nearer the upper epidermis.

It is these large parenchyma or giant cells that are most important in the unrolling of the leaves. When the leaf is young the fibro vascular bundles are poorly developed and there is a much greater uniformity. in the size of the parenchyma cells than in the mature leaf. The fibro-vascular bundles mature with the increase in age and certain of the parenchyma cells near the inner or upper epidermis increase in size very rapidly and become the giant cells. The lateral enlargement of these giant cells force the leaves to unroll and assume the normal position.

These large cells are probably filled with water and with the unrolling of the leaf they are exposed to the direct rays of the sun which naturally aids evaporation. The loss of water from these cells naturally results in a contraction and upward rolling of the cells which is so characteristic of plants of this kind during periods of drouth.

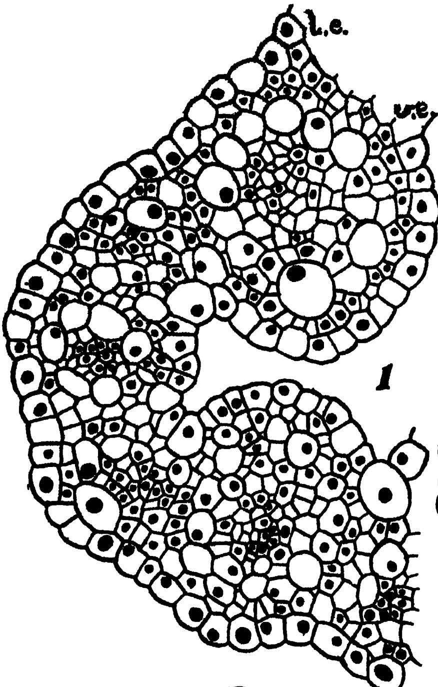
EXPLANATION OF PLATES

Fig. 1.—Cross section through a very young leaf before it has started to unroll. *u. e.*=upper epidermis. *l. e.*=lower epidermis. Note the very young fibro-vascular bundles; the uniform character of the mesophyll cells, some few of which are enlarging.

Fig. 2.—Cross section of an older leaf just starting to unroll. Note the increased development of the fibro-vascular bundles and the great variation in size of parenchyma cells as compared with Fig. 1.

Fig. 3.—Cross section of a leaf fully unrolled. Note the fibro-vascular bundles which are almost fully developed and the great variation in size of the parenchyma cells. Note the very large parenchyma cells near the upper epidermis. It is the lateral enlargement of these cells which forces the unrolling of the leaf.

PLATE I



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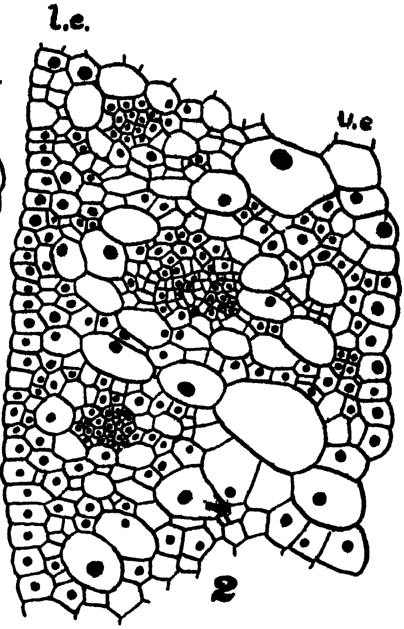

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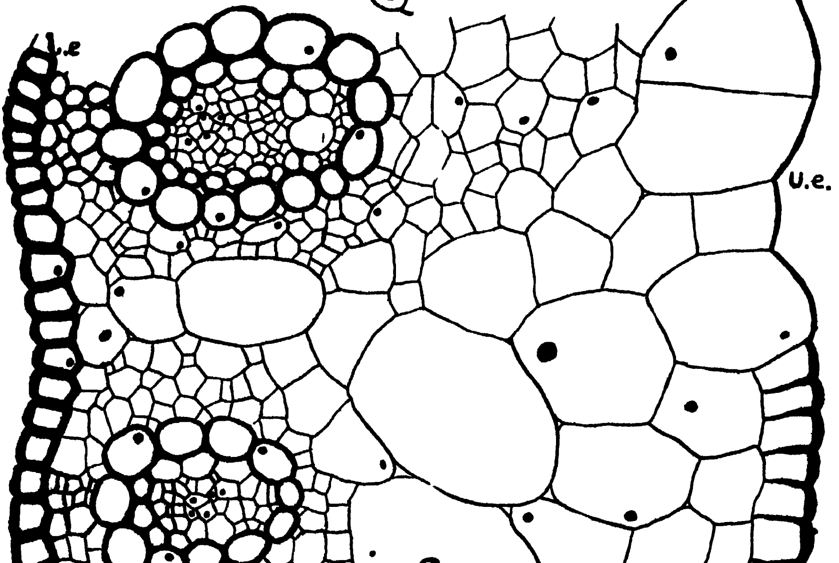

3

ONION-LEAF ANTHRACNOSE

J. A. B. NOLLA, Assistant Plant Pathologist

The fungus flora of Porto Rico has been the subject of detailed study during the last decade. A number of investigators have worked assiduously on various problems involved and have made very important additions to our knowledge of the subject. The present paper comprises the study of a new anthracnose disease of onions which was discovered by the writer in one of the eastern districts of the Island in January 1924.

The destructive nature of the disease makes its study of interest not only to Porto Rico where onion-growing promises to become an important industry but to other onion-growing countries in the world, in which this crop so far as reports go, is not subject to this malady. There is here presented a brief report on the investigation of this disease and a description of the pathogene. A popular account was published by the writer in 1925 (4). A note on this disease was also given by Cook (1).

SUSCEPTS

Allium cepa L. (Market onion) has been most seriously affected and the false shallot to a lesser extent. Infection has been produced on the latter, both under laboratory and field conditions. Plants of all ages are equally susceptible, although most of the damage appears to occur in plants three months old and during rainy weather. However, that plants of this age happen to be so seriuosly attacked under the prevailing weather conditions, is no indication that they are at this age most highly susceptible. The outbreaks of this disease here recorded appear to be correlated with the amount of rainfall and the length of the rainy periods.

Varietal Susceptibility

The work of Walker (5, 6, 7) on the resistance to onion smudge, which is also an anthracnose disease, led the writer to undertake a comparative study of the resistance of white, yellow and red varieties to the pathogene in a field of about .60 acre. Seedlings 40 days old were transplanted to plots 4 X 40 feet. Four plots were planted to red onion (Red Wetherfield and Red Bermuda), four to White onion (White Bermuda) and the rest of the field to yellow onion (Yellow Globe and Yellow Bermuda). The disease made its appearance at about the same time on all varieties. Careful observations showed that red, yellow and white varieties are equally susceptible. The tropical varieties (Bermuda onion) showed no less susceptibility to the pathogene than the temperate-zone varieties tested.

DISEASE

We have named this disease the *"Onion Leaf Anthracnose"* to avoid confusion with smudge which is often referred to as "onion anthracnose" and with diseases known as "onion leaf-spot".

History and Range.

As stated before in this paper the disease was first found by the writer in January 1924, in the eastern part of Porto Rico. In 1925 it was found in one of the northern districts and in the same farm where it had been discovered in 1924. In 1926 and 1927 material with anthracnose infection was obtained from the northwestern and northern sections. It does not appear to have been reported outside of Porto Rico.

Importance.

Data were gathered on the number of plants which were entirely killed by the disease, those which did not attain full maturity and those which were only slightly affected. Comparison of the yield from an uninfected field with conditions otherwise similar to those of diseased plots were made. From our observations it appeared that from 45 to 55 per cent of the crop was lost.

The damage to the bulbs while usually indirect is generally severe. The disease prevents the complete formation of the bulbs when the attack is early. In this way bulbs from diseased plants will be undersized. When attacks are late the disease opens the way for bacterial or other rots.

SYMPTOMATOLOGY

Morphologic Symptoms.

The disease is primarily of the leaf blade but the bulb scales may also be affected. The characteristic morphologic symptoms on white and yellow varieties are elliptic or oval tiny whitish spots which grow in all directions. During rainy weather the pathogene causes a rotting of the tissues. This destruction extends along the surface of the leaves and down to the bulb scales. Inner-bulb scales are not affected.

The symptoms on the red onions, especially the Red Wetherfield, are similar to those of the yellow and white varieties except that in the early stages of spot formation a red stain becomes prominent on all the injured tissues. This color soon takes on a violet appearance. This violet stain occurs before any fruiting bodies arise and disappears with age.

The diseased tissues in all varieties become paper-like and brittle when dry. Old spots may be almost colorless, but more commonly they are yellowish. They are sub-elliptic to irregular in shape.

Signs.

Conidia are produced abundantly in acervuli in the spots. The spore masses are creamy, flesh-like or pink to ferruginous. Ascospores may be found under certain conditions.

Histologic Symptoms.

The effects on the diseased tissues are those characteristic of necrotic diseases. As has been already stated the first indications of the disease are minute spots. These lesions enlarge. Hydrosis is the first histologic symptom which accompanies the penetration of the pathogene, which establishes both intra- and inter-cellular relationship. This is followed by the disorganization of the protoplasts and discoloration of the cell walls. This brings about a collapse of the cells, the first to succumb to the effects of the pathogene being those of the pallisade layer. The fungus penetrates farther down into the outer parenchyma cells, desintegrating them and then into the vascular bundles where it runs through and between the cells. Toward the later stages all that is left of the tissues is a skeleton of epidermis and broken cell walls

ETIOLOGY

Name, History and Classification of the Pathogene.

The pathogene under consideration was first thought to belong in the genus Gloeosporium. Later setae were found, which places it in the genus Colletotrichum. Since the fungus appears to be new to science it is given the name *Colletotrichum Chardonianum* in honor of Carlos E. Chardón, the present Commissioner of Agriculture and Labor of Porto Rico.

COLLETOTRICHUM CHARDONIANUM spec. nov.

Mycelium is hyaline, white gray or dark and even greenish, depending on the medium in which it is growing. It is 1.41–6.63 u thick, septate and profusely branched. (Pl. I, Figs. 10 and 11.)

Acervuli applanate, scattered, or gregarious (Pl. I, Figs. 30–31). These arise under the epidermis and break through it. They vary in color from ferruginous to brown, sometimes flesh-colored. The setae are brown, septate, slender, acute. in a few cases blunt at the tips, 98–170 × 4.8 u (Pl. I, Fig. 1). Conidia are oblong, in the majority of cases have both ends rounded. In some cases only one end is rounded while the other tapers to a blunt end. In other cases they are slightly curved, 6–80 × 1.7–7.0 u (Pl. I, Fig. 14). The conidiophores are simple, cylindric, terete or with rounded base and pointed tip, 7.9–79.5 × 1.72–3.7 u (Pl. 1, Figs. 12 and 13). A few perithecia were once found in culture, but were not produced later. The writer does not feel justified in making a description of the perfect stage from the insufficient material on hand and his failure to obtain it repeatedly.

CULTURAL CHARACTERISTICS

Pure cultures of the fungus were obtained in the usual manner and a study was made of its behavior in different artificial media. From pedigree cultures, poured plates of saccharose (3 per cent) agar, glucose (3 per cent) agar, lactose (3 per cent) agar, potato-dextrose agar, corn-meal agar and oatmeal agar, were inoculated. Measurements of colony growth in centimeters were made. Conidia were also measured.

On Potato-dextrose agar.

Neutral gray discoloration of the substratum; aerial mycelium in dense tufts, gray, growth profuse; acervuli salmon or ochraceous salmon.

On Oatmeal Agar.

Medium unchanged in color, mycelium hyaline or whitish, greenish masses here and there, acervuli numerous, ochraceous salmon or flesh-ocher, in distinct zones, but later filling up all the inter-zonal region.

Corn-meal Agar.

Substratum underlying acervuli brown to black; aerial mycelium scanty or none,[1] when present consisting only of short threads, hyaline; acervuli numerous, flesh-ocher to apricot buff, in zones or scattered.

Glucose Agar.

Substratum underneath acervuli mummy brown; aerial mycelium dull white and in some places smoky or dark, acervuli large, flesh-ocher or apricot buff to cinnamon-rufous, in zones; setae present, numerous.

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[1] The pedigree cultures used were under one month of age when fruiting is heavy. Older cultures show less fruiting.

Saccharose Agar.

Substratum Dresden brown underneath the acervuli, ochraceous-tuff elsewhere; aerial mycelium profuse, dark, over old growth, white; acervuli numerous, large, rufous to ferruginous, zones not well-marked, setae few.

Lactose Agar.

Substratum flesh-colored with mummy brown discoloration under old acervuli; aerial mycelium in short, whitish threads, scanty; acervuli numerous, large, flesh-colored to ferruginous, zoned at first.

Dextrine Agar.

Substratum unaffected in color, aerial mycelium scanty, short, white threads; acervuli numerous, large, rufous to ferruginous, not zoned.

TABLE I

SEVEN-DAY-OLD GROWTH OF *C. Chardonianum* n. sp. IN DIFFERENT ARTIFICIAL MEDIA

(Diameter of growth in centimeters)

Culture	Potato dextrose agar	Oat-meal agar	Corn meal agar	Glucose agar	Saccharose agar	Lactose agar	Dextrine agar
1	8.0	7.8	7.0	8.0	8.1	7.7	7.4
2	8.0	7.8	7.0	8.0	8.0	7.6	7.5
3	8.3	7.8	7.8	7.8	8.0	7.7	7.5
4	8.3	7.8	7.8	7.7	8.0	7.8	7.5

Pathogenicity.

Inoculation experiments were made as follows:

(*a*) A small portion of a healthy plot of onions (24 square feet) was sprayed with a suspension of conidia obtained from fresh lesions. This was done at 4 P.M. on a day in January. The plants were not protected from the sun and they received no watering. However, the air was warm and moist. It was conducted during a rainy period. Symptoms as already described (small whitish spots) appeared in from 3 to 5 days. Out of 34 plants so sprayed 31 showed symptoms at the end of 5 days.

(*b*) Strong, vigorous plants in clay pots were similarly treated. In this experiment the plants were covered with bell jars lined with moist filter paper. Symptoms appeared in from 3 to 5 days.

These two series of experiments prove beyond any possible doubt the power of *C. Chardonianum* to produce infection of onion plants.

Life History.

The life history of this pathogene probably involves only the asexual or conidial stage, although the sexual stage may also occur in the field.

The primary cycles occur as lesions on leaves of full-grown transplants in the field.

PATHOGENESIS

Inoculation.

Infected debris from the previous season is probably the chief source of the inoculum. It seems possible that the mycelium of the fungus is carried over to succeeding seasons in these old plant fragments. When the rainy season approaches, coincident with maximum development of the onion plant, it appears that a conidial crop is produced from this hibernating mycelium. Spattering rain brings about the transfer of the inoculum (conidia or perhaps ascospores) from this debris to onion leaves. Here the primary cycles are started, which by subsequent production of pink or creamy conidial masses furnish a constant source of inoculum for the secondary cycles.

INCUBATION

Germination of conidia was studied in Van Tieghem cells in the usual manner, at a temperature of 21° C. The first evidence of protrusion of germ tubes appeared at the end of three and one-half hours and germination was at its maximum at the end of four and one-half hours.

The spores of this species like those of most species of Gloeosporium, Colletotrichum and Glomerella, become septate prior to germination. Germ tubes grow from the ends of the spores (Fig. 18, 20, 23), although not infrequently from the sides (Fig 16). Germ tubes are of various lengths and in almost every case an appresorium is borne at the tip (Figs 17–22) of each tube. The plasmic contents of the spore creep into the appresorium and a septum is laid, thus cutting it from the germ tubes (Figs. 17–23). Primary appresoria germinate by sending out penetration tubes which enter the suscept and develop into a myclium or by production of secondary or tertiary appresoria. It is evident that appresoria may be subsequently produced again and again from primary or initial appresoria depending on environmental conditions. The spore upon falling on the infection court probably makes a first attempt to germinate, sending out a germ tube whose elongation may be arrested by want of moisture. An appresorium is formed at the end of the short tube. This is able to withstand unfavorable conditions. When better conditions of humidity are restored the appresorium in turn attempts to germinate in the same manner as the conidium. In this way several appresoria may result from one conidium before entrance or penetration is effected.

The germ tubes enter through the stomata of the leaves or through wounds, but penetration may occur through the cuticle probably by mechanical pressure as reported by Dey (2) for *Colletotrichum lindemuthianum*. The germ tube upon effecting entrance or penetration undergoes a change into a thicker hypha or primary mycelium, Leach (3). Further development of the pathogene brings it into a closer relationship with the suscept parts manifested in a series of changes which constitute infection.

Infection.

The primary mycelium makes its way into the epidermal cells, which it soon destroys. It runs between the cell wall and the plasma membrane. After reaching this stage the mycelium sends out any number of hyphae which grow in every direction, penetrating and killing the cells. These hyphae branch again and again and soon the tissues are traversed by the infecting hyphae. The necrotic spmptoms which accompany the infection of the tissues are the result of the reaction of the suscept cells to the substances produced by the invading hyphae. Toxic substances are probably produced soon after invasion since the latent period of infection appears to be short (2–4 days) and furthermore, the succession of changes from hydrosis to complete cell disorganization, seems to come with considerable rapidity. Under favorable conditions of atmospheric humidity, acervuli soon arise over the surface of the lesions. They are formed in breaks of the epidermis and may grow together in masses. Conidia make up the greater bulk of these masses which are pinkish or creamy. These spores constitute the inoculum for the cycles.

SAPROGENESIS

All observations tend to show that the mycelium in the necrotic areas of the leaves, lives over in a saprophytic manner until the coming season. Conidia are produced during the saprogenesis stages and furnish the inoculum for primary cycles. Whether one or more crops of conidia are produced by the mycelium in this stage is not known.

Secondary cycles constitute the most important phase in the disease. They are initiated continuously by conidia produced in the primary cycle and are in all respects similar to the primary cycles.

EPIPHYTOLOGY

That stage in the life of the suscept, just before or during bulb formation, seems to furnish the most favorable conditions for the attack of the pathogene.

Temperature.

Spore suspensions of the fungus were incubated at different temperatures. It was demonstrated that spores fail to germinate at 15° C and below. The following are the results of germination in tap water at different temperatures: At 18° C., 39.15 per cent; at 21° C., 41.92 per cent, at 25° C., 92 per cent; at 27° C., 86 per cent; at 30° C., 80 per cent; at 33° C., 64 per cent. Parallel trials conducted with distilled water showed that germination is equally good in distilled water as in tap water. It is seen that germination is at its maximum at 25° C. but is poor at lower temperatures of 21° C. and 18° and at a higher temperature of 33° C. In the field the range in which the disease seems to appear more commonly is 23° C.–30° C. In cultures the optimum temperature seems to be 27° C. See table II. In general, in the three media growth was best at 27° C. with maximum production of conidial masses.

TABLE II

SEVEN-DAY-OLD GROWTH OF *Colletotrichum Chardonianum* IN CENTIMETERS IN DIAMETER

Temperature	Potato dextrose agar	Corn-meal agar	Oat-meal agar
6° C.	0	0	0
9° C.	0.1	2.3	1.0
12° C.	2.2	4.5	3.6
15° C.	2.7	3.8	5.2
18° C.	5.5	6.0	6.3
21° C.	7.5	7.5	7.6
25° C.	8.5	7.8	7.8
27° C.	9.0	7.8	7.8
30° C.	8.0	7.0	7.0
33° C.	7.8	7.0	6.5

We do not feel justified in assuming temperature to be the most important factor in epiphytotics although coupled with moisture it may have great influence in limiting their extent and destructiveness.

Moisture probably plays the most important role in determining the nature and severity of outbreaks of this disease. It seems essential in effecting the dissemination of conidia. The occurrence of the disease in the field and the production of secondary cycles is dependent to a large extent on precipitation.

CONTROL

It is quite doubtful whether we can resort to any eradicatory measure in the control of this disease. The removal of diseased leaves and plants to prevent further spread of the pathogene sounds logical, but general practice tells us it is highly improbable that the average farmer will gain anything by that method. The production of conidia under field conditions in such great numbers curtails the possibilities of the application of this eradicatory practice, since secondary cycles will occur with the same ease.

Protection.

Spraying and dusting with suitable liquids or dusts will eventually come into use more and more. Three factors should be considered in the general application of these protective methods, namely, the cost of application as compared to the gains from it, the adhesive power of the dusts or liquids and the general effectiveness of these fungicides.

Preliminary laboratory trials have been conducted with various dusts to find the effect on the spores of the pathogene. Those tried were: Kolo-dust, dusting sulphur, copper lime dust, Banks' Colloidal copper, corona colloidal copper, copper hydroxide and Killtone copper dust.

The following results were obtained in triplicate trials with spore counts of 4,000 and using the dusted-slide method employed at Cornell University.

Corona colloidal copper	no	germination
Banks' colloidal copper	36.47%	germination
$Cu(OH)_2$	37.40%	germination
Killtone copper dust	9.00%	germination
Copper lime dust	62.84%	germination
Kolodust	57.47%	germination
Dusting Sulphur	60.50%	germination
Check	59.50%	germination

General observations of the germination processes.

In Banks' Colloidal copper brown appresoria were abundant, produced successively from the same germ tube; germ tubes are very long and normal in growth, soon giving rise to a cobwebby mycelium. In copper hydroxide no appresoria were observed and germ tubes were very short; this was also the case with Killtone copper dust. Kolodust: appresoria abundant and germ tubes long Dusting Sulphur: appresoria present; germ tubes extremely long, much more so than in Kolodust. Copper lime dust: appresoria present; secondary conidia also produced in large numbers; germ tubes very long and profusely branched. The failure of sulphur dusts to inhibit spore germination is in line with our general knowledge of the non toxic properties of the sulphur fungicides to anthracnose fungi.

The data and observations given above on the germination of conidia of *C. Chardonianum* in various fungicides suggest a rather effective action of Corona colloidal copper, Killtone copper dust, Banks' Colloidal copper and copper hydroxide. Apparently the first two are more promising than any of the others. However, it must not be overlooked that the adhesiveness of these dusts to the waxy surface of the onion leaf has to be tested before any more definite steps to their application in the field are attempted. So far the writer has been unable to test the adhesiveness and relative efficiency of these fungicides under field conditions.

SUMMARY

(1) An anthracnose disease of the leaves and bulb scales of the onion is described.

(2) Market onion (*Allium cepa L.*) and a multiplier variety of *Allium cepa* L. often referred to as false shallot are affected.

(3) There does not exist any resistance in the yellow, red or white varieties to the disease.

(4) Tropical varieties of onion are as susceptible as the temperate-zone types.

(5) Plants of all ages are equally susceptible.

(6) The symptoms on the leaves may be described as elliptic or oval spots. On red varieties a red stain appears on young lesions.

(7) The pathogene is described as a new species, *Colletotrichum Chardonianum.*

(8) Growth of the causal fungus in carbohydrate media was excellent. It was especially good in starch-containing media.

(9) Infection experiments under control conditions demonstrate the ability of *C. Chardonianum* to produce disease. Infection occurs primarily through the stomata but the germ tubes may penetrate through the cuticle.

(10) Conidia germinate in water at a temperature of 21° C. in 3½ to 4½ hours. During germination of conidia, primary, secondary and even tertiary appresoria are produced. Also secondary conidia. Temperatures of 18° C. and 33° C. seem to inhibit germination, while conidia germinate readily at 25° C. In synthetic culture media the fungus grows best at a temperature of 27° C. In the field the disease appears during seasons when temperature is 23° C–30° C.

(11) The pathogene apparently lives over from one season to the other as mycelium in debris on the soil.

(12) The conidia seem to resist the action of the sulphur fungicides. An effective action of copper fungicides, particularly colloidal copper, has been observed in laboratory experiments.

This investigation was begun in the Insular Experiment Station but the bulk of the work was done in the Laboratory of Plant Pathology, Cornell University, Ithaca, N. Y.

I owe an acknowledgment to Dr. Mel. T. Cook, Chief Pathologist, for helpful advise during the early studies on this disease, to W. R. Fisher of the Department of Plant Pathology at Cornell University, who kindly made some of the photographs, and finally to Prof. H. H. Whetzel of the Department of Plant Pathology, Cornell University, for valuable suggestions and criticisms and for reading the manuscript.

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PLATE I

Fig. 1 = Setae of *Colletotrichum Chardonianum* n. sp.
Fig. 2 = Two fertile hyphae conjugating.

Fig. 3 = Fertile hypha with terminal conidium.
Figs. 4 and 7 = Fertile hyphae.
Figs. 5, 6, 8 and 15 = Types of fertile hyphae with terminal conidia.
Fig. 9 = A fertile hypha with cells giving rise to one-celled conidiophores which bear conidia at the tips.
Figs. 10 and 11 = The mycelium of *C. Chardonianum.*
Figs. 12 and 13 = Conidiophores of *C. Chardonianum* bearing conidia at the tips.
Fig. 14 = Conidia of *C. Chardonianum.*
Fig. 16 = Germinated conidia conjugating..
Figs. 17 and 22 = Conidia germinating in water, giving rise to primary, secondary and even tertiary appresoria.
Figs. 18 and 20 = Two conidia germinating by a short tube and an appresorium.
Fig. 19 = A conidium germinating and producing primary and secondary appresoria.
Fig. 21 = A germinating conidium with primary appresoria.
Fig. 23 = Conidia germinating into a long tube bearing at the tips secondary spores.

PLATE II

Fig. 24 = A longitudinal section through a healthy onion leaf (outlined with aid of camera-lucida).
Fig. 25 = A section through a lesion of a diseased leaf. Note the hyphae penetrating through and running between cells. The destruction of the palisade cells is evident.
Fig. 26 = Another section through a diseased leaf showing destruction of palisade cells and also hypha penetrating through cells of vascular bundles.
Fig. 27 = View of surface of onion leaf showing a few spores germinating and penetrating through the stomata. Note the production of appresoria. (Outlined with aid of a camera-lucida.)
Fig. 28 = Section through epidermis showing an appresorium germinating and the tube penetrating through a stoma. The very early stages of a pathological condition: branches of the primary mycelium penetrating the suscept cells.
Fig. 29 = Meyclial threads (hyphae) as seen within and between cells in the vascular bundles (highly magnified). (Outlined with aid of camera-lucida.)

PLATE III

Fig. 30 = Shows lesions on the leaves of onion. The leaf on the left shows the early stages of the disease; that on the right the more advanced stages with masses of acervuli.
Fig. 31 = Enlarged base of the onion plant of Fig. 32 showing the acervuli of the fungus arising on the surface of the leaf bases. Notice poor root system from imperfect nutrition.
Fig. 32 = Typical case of onion plant affected with *C. Chardonianum.* Notice the diseased leaves and the bases of leaves already destroyed.
Fig. 33 = Culture of *C. Chardonianum* on hard potato dextrose agar.

PLATE I

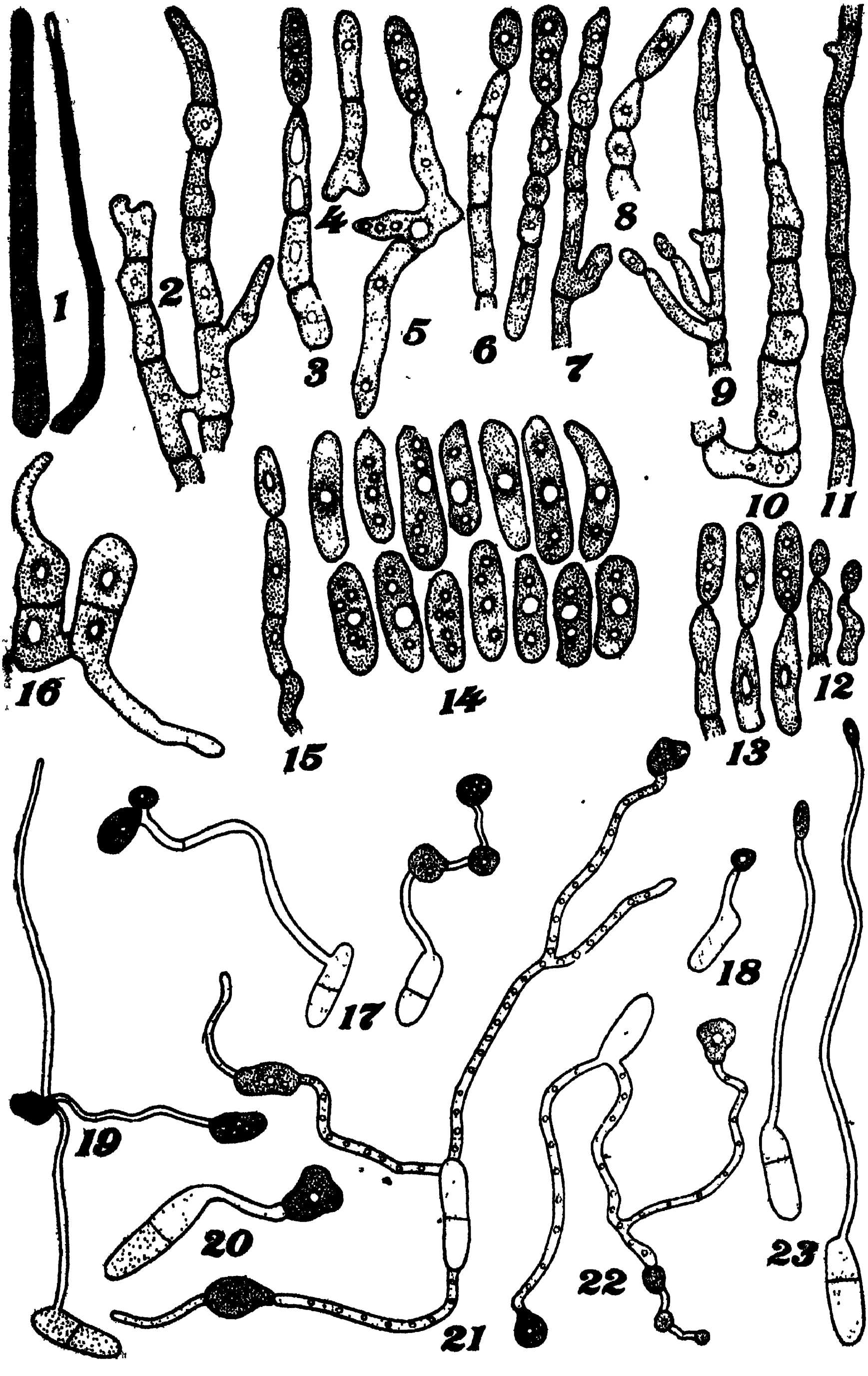
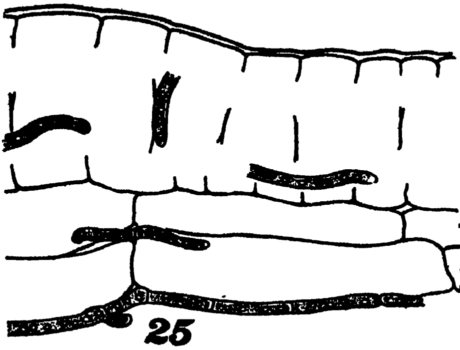


PLATE II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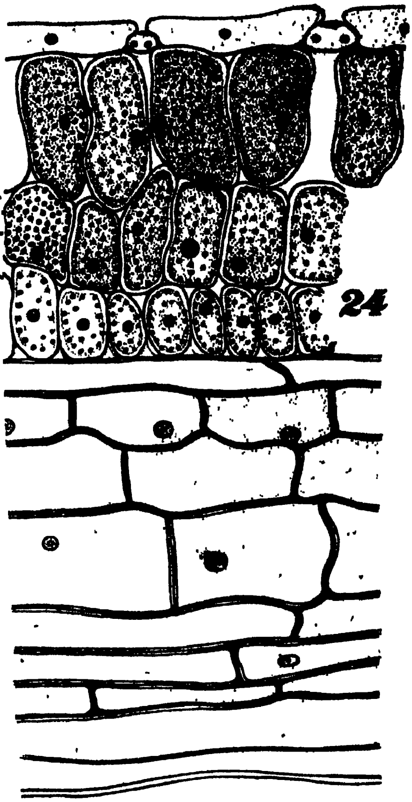
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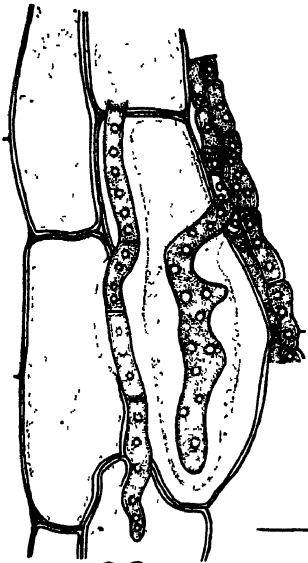
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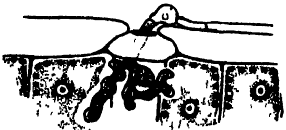
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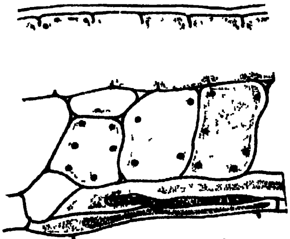
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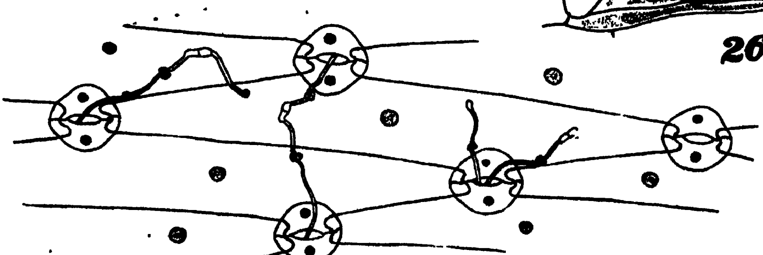
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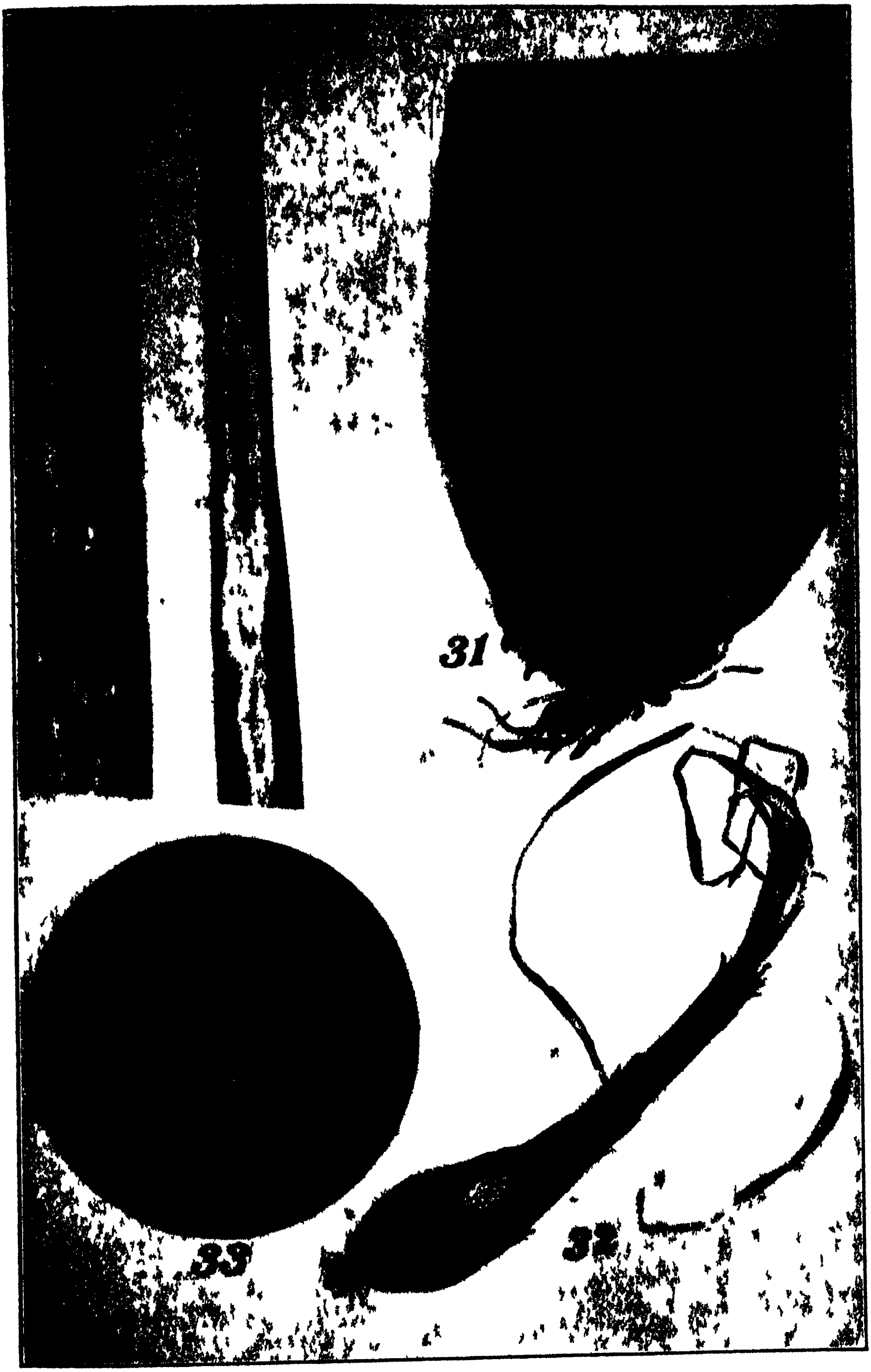
PLATE III



MANGO WITHER-TIP

(*Colletotrichum gloeosporioides* Penz.)

J. A. B. Nolla, Assistant Plant Pathologist

The fungus *Colletotrichum gloeosporioides* has been reported from time to time as causing troubles of various kinds on a number of suscepts. However, its true pathogenicity or active parasitism has been the subject of much speculation and a matter of conjecture. On citrus fruits, for instance, *C. gloeosporioides* has been held not to be an active pathogene, Smith (3) and Fulton (1). Winston (5), using a large number of strains of *C. gloeosporioides,* found no active pathogenicity exhibited on young fruits of various citrus species. Nowell in his book on diseases of tropical plants, page 211, states it is mainly a saprophyte. The author (2) came forth with the statement that this fungus is an active pathogene in Porto Rico. He found it to be the cause of a heavy drop of the young fruits of the orange, pomelo and Chinese dwarf lemon.

In the present short paper the writer intends to bring more evidence of pathogenicity of strains of *C. gloeosporioides.* He almost predicted the ability of *C. gloeosporioides* to produce wither-tip on the mango (2), when he stated that "mango twigs when tender seem to be susceptible to the attack of *Colletotrichum gloeosporioides*" (see his plate I, fig. 3). This statement was based on results which he obtained with spore-spray inoculations of avocado, mango and pomelo strains of *C. gloeosporioides* on the unopened buds of the mango.

Early in November 1926 the writer directed his attention to a few mango trees in the station grounds. It was during a short dry spell and there were no signs of a fungus infection. Two weeks later, with the coming of heavy rains and a new flush in the trees, there occurred a very rapid withering of the young tender twigs and buds. There was also considerable spotting of the leaves, manifested as tiny, brownish spots between the main veins, which later increased in size. This resulted in long, sometimes narrow, necrotic areas on the tender, pinkish leaves which caused a breaking and splitting at the infected areas. Soon, the infection which apparently starts in and around the unopened leaf buds, extends down the shoot as far as the upper limit of the preceding growth. The tender foliage soon dies and falls to the ground. Acervuli of the fungus appear readily on the surface of the withered twig, especially on the scars left by the leaf petioles.

Isolations were made from various places of infection. Spore-spray inoculations with pure cultures of the pathogene were made, covering the buds in the best manner to insure control conditions. The same symptoms as observed with natural infection were reproduced with artificial inoculations. The pathogene, *C. gloeosporioides*, same strain as used in inoculation was recovered from the infected twigs.

This is a case where a fungus held to be a saprophyte under many circumstances, exhibits in some of its strains a strictly parasitic action on one of its suscepts. We might here recall a similar situation existing with *Macrosporium parasiticum* Thüm, the cause of the black mold of the onion, whose pathogenicity has not been fully accepted. Teodoro (4) has pronounced it as an aggressive parasite. Others have held rather dubious views as to its secondary nature.

It seems probable that fungi which have heretofore been known as saprophytes or weak parasites on necrotic areas of living plants, or the intermediate living tissues, will gradually, through adaptation, bring about changes in their ontogeny which will eventually place them in the category of the more highly specialized forms—the active parasites.

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FIG. 1—Mango tree with a severe infection of *C gloeosporioides* on the twigs

SOME NEW AND INTERESTING PORTO RICAN LEAFHOPPERS

By H. L. DOZIER[1]

Opportunity is here taken to publish a few interesting records and additions to the leafhoppers of Porto Rico. The writer wishes to thank Mr. W. L. McAtee of the U. S. Biological Survey for determining specifically the Eupterygid species included in this paper.

FIG. 1.—Leaves of Roble, *Tabebuia pallida*, showing the work of *Protalebra tabebuia* Dozier

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[1] Formerly Chief Entomologist of the Insular Experiment Station

Protalebra tabebuiae, new species

Head rather broadly rounded although slightly produced. Venation of wings typical of the genus.

General color of body pale yellowish-white, the vertex and thorax in most specimens with a broad median longitudinal band of orange on dorsum; ground color of the elytra a golden yellow with the inner claval margin, an oblique band across the middle, and another band beginning at the hind margin of the clavus and running across the cross veins, distinctly fuscous; in some specimens there is a Chinese-white irregular patch on the outer costal margin just above the middle fuscous band; the crossveins infuscated, the apical area denoted by them is hyaline. Legs whitish.

Length to tip of elytra, 2.75 mm.

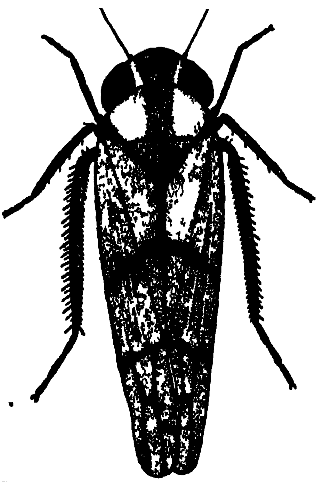

FIG. 2.—Adult of *Protalebra tabebuiae* Dozier (Original)

Described from numerous specimens of both sexes taken on underside of leaves of "Roble", the West Indian Box Tree, at Río Piedras, Porto Rico, March 10, 1925. It was found abundant in all stages October 22, 1924, and has been observed to be rather abundant throughout the entire year. "Roble", *Tabebuia pallida*, is widely used as a shade tree in Porto Rico and its wood is of much economic importance. While this leafhopper often becomes very abundant on it, causing considerable "speckling" of the foliage, the Roble is so hardy that it is able to support large numbers without any apparent injury.

Protalebra similis Baker

(1899 Psyche, 8, p. 403)

A dozen adults were swept by the writer from sweet-potato foliage at Vega Baja, Porto Rico, October 15, 1924. It does not appear to be at all abundant.

Protalebra brasiliensis Baker

(1899 Psyche, 8, p 405)

This species is the most abundant and generally distributed *Protalebra* in Porto Rico being commonly met with in cane fields and in weedy places. It is the same species discussed and figured by Wolcott (Jr. of the Dept. of Agri. of Porto Rico, V, p. 31) under the name *Erythroneura comes* Say.

Protalebra bifasciata Gillette

(1898, Proc. U. S. Nat'l. Mus., 20, p. 711)

A single specimen taken by beating a thorny leguminous bush in ravine near Juana Díaz, Porto Rico, February 11, 1925. Recorded from Brazil and Jamaica.

Empoasca minuenda Ball

(1922, Proc. Ent. Soc. of Wash., Vol. —)

The writer found this very small species abundant on undersides of avocado leaves at Río Piedras, Porto Rico, October 22, 1924, and it also attacked the young avocado nursery stock at the Insular Station in large numbers.

Dikraneura (Hyloidea) depressa McAtee

(1926, Jr. New York Ent. Soc., Vol. XXXIV, p. 162)

This species has been recently described from two females and a male collected by G. N. Wolcott at Vega Alta, Porto Rico, January 21, 1920, and the new subgenus Hyloidea erected for it based on the extraordinary depressed or flattened shape. The original description is given here to make it more available to workers in Porto Rico:

> "Female: Head and thorax yellowish in ground color with a percurrent russet to dusky marking covering all but narrow anterior margin of vertex, disk of pronotum, and all but extreme lateral angles of scutellum; apical third of scutellum jet black. Tegmen lemon yellow, a dusky blotch on middle of clavus, a dusky band over inner crossveins, and a jet black spot on first crossvein; tegminal apex sometimes touched with dusky. Underside stramineous throughout except for the black apex of ovipositor; bristles on ovipositor sheath white. Eighth sternite convex medianly, slightly concave laterally. Male similar to female, marking of head and thorax more or less tinged with reddish laterally; tegmen anterior to fourth crossvein also with a pinkish cast. Venation as in Fig. 15. Length, 2.25–2.75 mm.
>
> "Holotype male, allotype, and another female, Vega Alta, Porto Rico, January 21, 1920, G. N. Wolcott (U. S. N. M.)."

These remarkable leafhoppers are to be found on the undersides of the leaves of *maga*, *Thespesia grandiflora*, in limited numbers. The writer found them abundant at Bayamón, Nov. 17, 1924, and made the following color notes. The last instar nymphs are of a general pale whitish color, the elytral pads pale with an orange-red longitudinal stripe; the sides of the pronotum and the head except the eyes orange; the eyes pale bluish; scutellum with reddish-brown markings; the second and third abdominal segments a deep reddish-brown. Length 1.75 mm. These nymphs remind one of

Uncle Sam's red, white and blue. Both the adults and nymphs lie closely appressed to the leaf surface, mostly along the mid-ribs, moving when disturbed with a "sideling" or sidewise movement, rarely jumping.

Joruma pisca McAtee

(1924, Fla. Ent., Vol. 8, No. 3–4, p. 34)

The writer took a single specimen at Aguirre, Porto Rico, March 1, 1925, that has been identified by McAtee as this species.

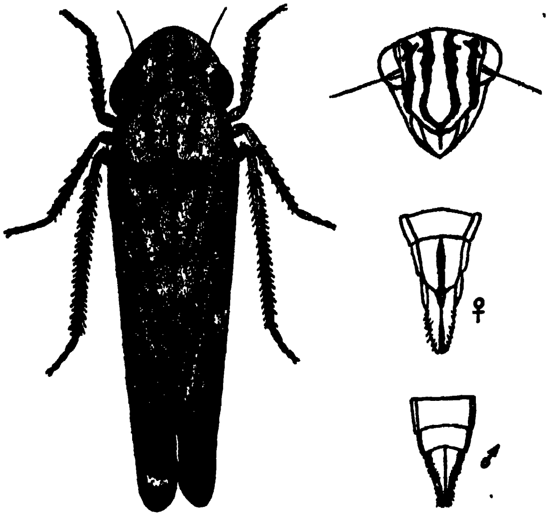

FIG. 3.—Adult female *Cicadella coffeaphila* Dozier, frons and genitalia (Original)

The two following species have been long confused with each other on acount of their very similar general appearance and habitat and have long been placed under the name *Tettigonia occatoria* Say (Wolcott, Insectae Portoricensis, p. 259). Upon examination of the large series in the collections of the Insular Experiment Station and the American Museum of Natural History, the writer found that they not only are not Say's *occatoria* but represent two distinct undescribed species. *Cicadella occatoria* is a somewhat smaller, less robust species, and has a single black dot on the pale frons just below the apex of the vertex margin (see Ball, Proc. Iowa Acd. Sci. viii, p. 23, 1901). The writer has not found *occatoria* either in his personal collecting in Porto Rico or in the various collections represented. Specimens, however, are at hand from the American Museum of Natural History collections, taken in June 1911 at Laudet and Long Ditton, Dominica, B.W.I., that must be placed as typical *occatoria*.

Cicadella coffeaphila and *C. coffeacola* are both abundant throughout the mountanous coffee-growing regions, particularly the former species, occurring on the coffee and many other host plants among which may be mentioned the jobo and *Inga laurina*. Both species so far are known only from the Island of Porto Rico and appear to be endemic.

Cicadella coffeaphila, new species

Distinguished at once from *Cicadella occatoria* by its larger size and different marking on frons.

Vertex as long as basal width, strongly produced beyond the eyes, obtusely sounded, nearly two-thirds as long as the pronotum. Pronotum convex, about as broad at posterior margin as the head. Elytra long and narrow.

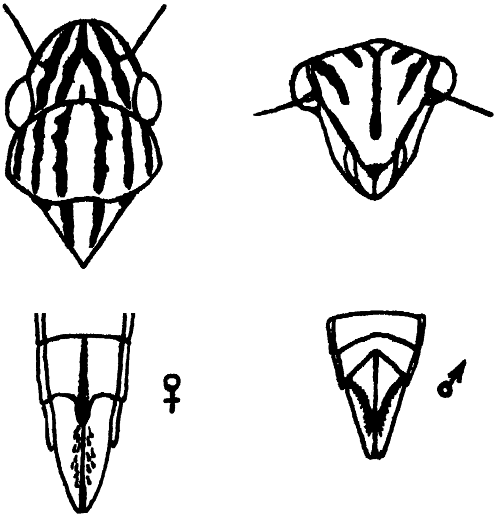

FIG. 4.—*Cicadella coffeacola* Dozier, showing head, frons, and female and male genital segments (Original)

General color greenish, the vertex, anterior third of pronotum, and scutellum partially, yellow. Vertex with four irregular more or less longitudinal stripes or vittae that extend over onto the frons where the two median ones converge just before the apex. Pronotum with five more or less broken and irregular black vittae. Scutellum with two rather thick black vittae. The elytra dark green with the veins heavily marked with black, just before the apex is a crescent-shaped transverse band of yellow. Body beneath yellowish, the abdomen along middle marked longitudinally more or less with black. Male genital plates distinctly yellow contrasting with the dark pygofers. Legs pale.

Genitalia: female segment over twice as long as the preceding, the median line elevated into a strong keel, the posterior margin strongly angled, the apex formed by the convex keel. Male ultimate segment well-rounded on posterior margin; plates broadened at base, rapidly narrowed to very long acute points that are not or scarcely exceeded by the pygofers.

Length to tip of elytra, 6–6.25 mm.

Described from numerous males and females in the collection of the American Museum of Natural History collected for the most part by Lutz and Mutchler from the following localities in Porto Rico: Cayey, May 30, 1915; Aibonito, June 1–3, 1915; Barros, June 4, 1915; Mayagüez, July 24, 1914, Frank E. Watson; Jayuya, June 1, 1915, H. E. Crampton; Adjuntas, June 26, 1915; and a female collected at Yauco, August 24, 1922, by Sein and Wolcott (Acc. 234–22); and a female collected by the writer on El Yunque, February 17, 1925.

Cicadella coffeacola, new species

Very similar in general appearance with *Cicadella coffeaphila* but easily distinguished by the different markings on vertex, frons and pronotum.

Vertex greatly produced beyond the eyes, obtusely rounded, length and width subequal, two-thirds as long as the pronotum. Pronotum about as broad at posterior margin as the head, convex. Elytra long and narrow.

General color greenish, the vertex yellow with four black stripes or vittae, the two median ones converging to a point at the apex, the outer lateral margins outlined with black. Frons yellow with black median stripe and the lateral ones of the vertex continued over on frons part of its length, the lower sides of frons with black edging; clypeus black. Pronotum greenish, yellow along the anterior third, six distinct black longitudinal stripes running semi-parallel. Scutellum yellow, with two black median stripes and a black spotting in the upper angles. Elytra deep green, the veins broadly marked in black. Body beneath for the most part yellow, the abdomen marked with broken black along median length. Male plates yellow, the pygofers black. Legs pale.

Genitalia: female segment twice as long as preceding, male ultimate rather deeply incised on hind margin; plates rather broad at base, rapidly narrowing to long acute points, greatly exceeded by the pygofers.

Length to top of elytra, 6–6.25 mm.

Described from a female taken at Río Piedras, Porto Rico, Aug. 1921, G. N. Wolcott (Acc. 266–21); a female collected by the writer on coffee, El Yunque, Feb. 17, 1925; and numerous males and females collected by Lutz and Mutchler in American Museum of Natural History collection from Cayey, May 30, 1915; Aibonito, June 1, 1915; and Adjuntas, June 26, 1915.

Macropsis rugicollis, new species

Easily distiguished by the striking contrast of the bright red head and thorax with the black body and elytra.

Form rather long. Anterior margin of the pronotum moderately and roundingly angulate, produced on the middle distinctly beyond the anterior margin of the eyes, the posterior margin only slightly emarginate. Elytra long with the tips broadly rounded, nervures raised.

Color: Entire head a bright red with exception of the very dark reddish-brown eyes. Pronotum bright red with a rather narrow band of black outlining its anterior margin but extending laterally only to about half the width of the eyes above. Remainder of the body, legs and elytra a dark blue-black.

Length, 5.50 mm.

Described from two males taken on the top of mountain at Cerro del Cacique, Santo Domingo, December 17, 1924, by F. Sein at about 5,000 feet elevation, probably from a shrub or tree as members of this genus are so far as known tree-inhabiting forms.

NOTES ON PORTO RICAN SCALE PARASITES

By H. L. Dozier[1]

The following notes are here given as a small contribution to our knowledge of the enemies of certain scale insects in Porto Rico. The writer wishes to express his thanks to Mr. A. B. Gahan of the United States National Museum for his kindness in helping to compare and identify the parasites recorded in this paper.

Leptomastix dactylopii Howard

(1885, U. S. Bur. of Ent., Bul. 5, p. 23)

This species was described briefly by Dr. Howard in 1885, and again in 1892 (Proc. Ent. Soc. Wash., II, p. 237) he states that is a not uncommon parasite of the common mealy-bug in the greenhouse at Washington, D. C., and notes the following:

> "Miss Lillie Sullivan has found it the present season infesting mealy-bugs upon house plants, and informs me that she can at once recognize infested scales by the fact that they lose almost entirely their wax or meal-like covering and swell up into yellow objects closely resembling dipterous puparia. She has shown me several from which the parasites have emerged and I have been greatly struck by this resemblance which is heightened by the fact that the parasite in issuing cuts off a cap at the end of the scale insect, just as the dipterous insect forces off the end of its puparium. This is an abnormal habit so far as I know, as allied parasites are accustomed to gnaw holes through their hosts, removing the epidermis in small particles and leaving no cap. The resemblance of the swollen mealy-bug to a dipterous puparium is so strong that only by close search with a strong lens can the observer, by finding the minute legs and antennae, be certain of its identity."

These early observations of Dr. Howard have been confirmed by the writer.

Upon further study and comparison of material, *dactylopii* may prove to be identical with the European *histrio* described by Mayr in 1875, and this is highly probable as both species seem to be rather variable in color and size.

Female: Head somewhat lenticular, slightly convex; ocelli arranged in triangle, the hind ones farther apart from each other than from the inner margin of the eye; antennae very long, as long or slightly longer than the body, slender and clothed with delicate short hairs; the scape as long as the first two funicle joints together, pedicel twice as long as wide, and about half as long as the following joint, club as long as the last two funicle joints com-

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[1] Formerly Chief Entomologist of the Insular Experiment Station

bined, slightly broader than the funicle and rounded on end. Thorax moderately arched, mesonotum somewhat shining, with scattered setae. Scutellum dull, with sparse setae; at its posterior apex are two distinctly larger, more prominent black setae. Vertex and thorax with indistinct scale reticulations under high microscopic power. Abdominal segments difficult to distinguish.

The general color of the female is honey-yellow with distinct reddish tinge on the mesonotum, the antennae and eyes blackish, the hind margin of the pronotum, scutellum, dorsum of abdomen, and hind femora more or less dusky.

FIG. 1.—*Pseudococcus citri* parasitized by *Leptomastix dactylopii*

Male: Similar to female in structure but distinguished at once by its antennae which are distinctly longer than the entire body and the funicle is furnished with numerous long hairs which are not arranged in whorls. Much darker than the female, the amount of black on thorax quite variable, the mesonotum, distinctly yellow. Antennae, hind tibiae and tarsi fuscous.

Length of female, 1.50 mm.; male, 0.97 mm.

As the original description is now inaccessible to most workers, the above brief re-description is given. It is drawn up from a female reared by the writer from *Pseudococcus citri* at Río Piedras, Porto Rico, June 8, 1925, and a series of three females and four males reared by F. Sein at same locality from the same host, November

1925. There is also at hand a male reared by the writer at New Orleans, La., September 1922.

Achrysopophagus seini, new species

Resembling a *Cheiloneurus* very closely and placed in *Achrysopophagus* only because of its slightly narrower head and the absence of distinct scrobal grooves. Very close to *A. dactytopii* Howard but differs in having the fore-wings less enfumed and the stigmal vein is very different.

Female: Head slightly wider than long; ocelli arranged in an acutely angled triangle. Antennal scape slightly expanded beneath, nearly four times as long as its widest width; pedicel as long as the first two funicle joints combined; first four funicle joints sub-equal, the fifth and sixth longer and wider; club three-jointed distinctly wider than the scape and of about the same length, obliquely truncate. Mesothoracic scutum over twice as wide as long. Scutellum about as long as wide, with the characteristic tuft of black bristles, distinctly reticulated. Mesoscutum with dark hairs anteriorly and on hind margin but with numerous setigerous punctures in the silvered area. Abdomen shorter than the thorax, the ovipositor sheath distinctly exserted.

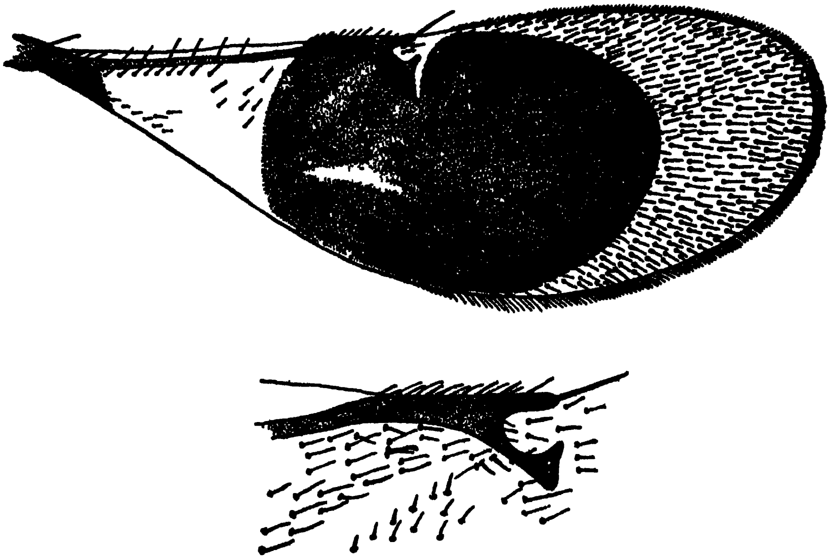

FIG. 2.—Forewing of female *Achrysopophagus seini* Dozier

General color a yellowish orange, the abdomen usually slightly darker; eyes dark. Antenna testaceous yellow except a fine streak along center of upper margin of scape, the pedicel, first funicle joint partly, and the club, which are brownish-black. Legs pale yellowish white, the hind femora and tibiae with slight infuscations. Fore-wings with characteristic enfumation on disc as in Fig. 2.

Length, exclusive of ovipositor, 1.10–1.4 mm.

Male: Antennae entirely different from those of female, easily differentiating the sexes, uniform light brown in color; funicle joints furnished with partial whorls of long diverging hairs. General color dark-brown, the front and middle legs pale, the wings hyaline without embrowning.

Length, .78 mm.

Described from a female reared by the writer (U. S. National Museum type No. 40351) from *Pseudococcus citri* material on croton at Río Piedras, Porto Rico, June 21, 1925, and a series of four females and one male reared by Francisco Sein in November 1925 from the same host and locality. The mealy bugs were parasitized by *Leptomastix dactylopii* and the parasitized individuals were placed in shell vials by Mr. Sein, and from some of these issued this species. *Arfchrysopophagus scini* is most probably secondary on the *Leptomastix,* although absolute proof is lacking. All material was mounted in Canada balsam on slides and is not entirely satisfactory.

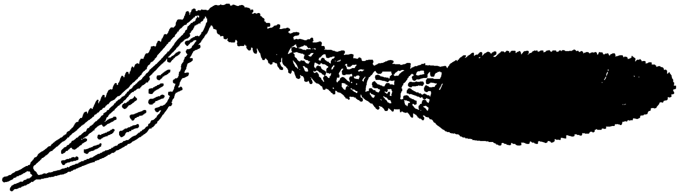

FIG. 3.—Antenna of female *Achrysopophagus seini* Dozier

Achrysopophagus gahani, new species

This species is very closely allied to *A. seini* and *dactylopii* How. and was first placed as the latter. The original description of *A. dactylopii* is too meager to allow for positive identification but through the kindness of Mr. A. B. Gahan of the U. S. National Museum the Porto Rican specimen was carefully compared by him with the type of *dactylopii* and found to be a distinct and apparently undescribed species, *dactylopii* having the ovipositor very distinctly exserted, the head decidedly longer than broad when viewed from the front, and the antennal club is much larger than in *gahani.*

Female: Antennal scape much expanded beneath, pedicel as long as first two funicle joints combined, the fifth and sixth joints distinctly wider and longer than the preceding funicle joints; club three-jointed, distinctly larger and wider than remainder of antenna.

Scutellum with the characteristic tuft of black bristles at apex, reticulated. Abdomen about as long as thorax, the ovipositor sheath only slightly exserted. The structure of the stigmal vein is very distinctive, readily separating it from *seini*.

General color yellowish orange. Forewings hyaline and bare on basal third except slight embrowning at base, remainder distinctly embrowned with only the apical tip hyaline as in Fig. 4. The antennal scape testaceous yellowish, lower edge infuscated along basal half, the pedicel and funicle distinctly darker yellowish-brown, the club deep fuscous.

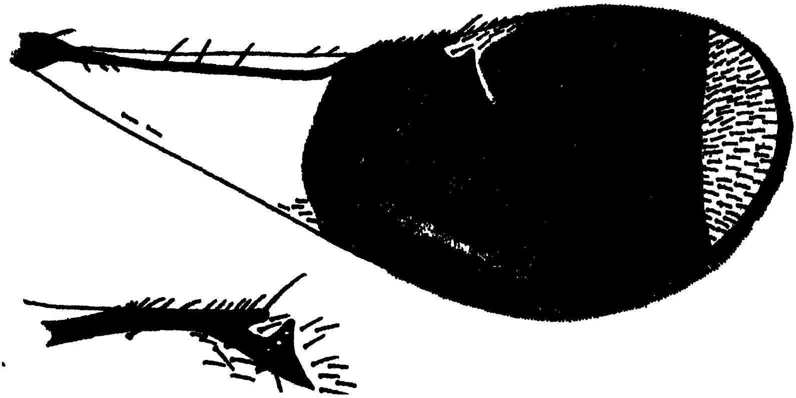

FIG. 4.—Forewing of female *Achrysopophagus gahani* Dozier

Length, exclusive of ovipositor, 1.25 mm.

Described from a single female reared by the writer from *Pseudococcus citri* material on croton June 18, 1925, at Río Piedras, Porto Rico (U. S. National Museum type No. 40352). It is most probably a secondary parasite. Dr. Howard in describing his *A. dactylopii* states that a large number were bred from the common mealy-bug in company with *Leptomastix dactylopii* Howard.

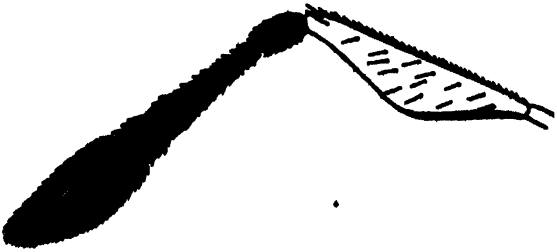

FIG. 5.—Antenna of female *Achrysopophagus gahani* Dozier.

Thysanus nigrus (Ashmead)

(1900 Proc. U. S. N. Mus., xxii, p. 410, *Signiphora*)

Two females of this species were reared by the writer at Río Piedras from *Pseudococcus citri* material on croton June 22, 1925, and a male was reared from similar material July 3, 1925.

Thysanus bifasciatus (Ashmead)

(1900 Proc. U. S. Nat. Museum, xxii, p. 411, *Signiphora*)

Four specimens reared in November 1925 by Francisco Sein from parasitized *Pseudococcus citri* placed in shell vials, have been compared by Mr. Gahan with the unique type of *bifasciata* and prove to be the same species. It is most probably hyperparasitic on either *Leptomastix dactylopii* or *Achrysopophagus seini*, both of which were reared from the same material. *T. bifasciatus* was described from a single female specimen collected by H. H. Smith on St. Vincent, and it is interesting to have more definite information concerning this distinctly West Indian species.

Thysanus flavus (Girault)

(1913 Proc. U. S. N. Mus., 45, p [illegible], *Signiphora*)

A single female was reared by the writer from lignum-vitae material infested with *Aleurothrixus howardi* at Central Aguirre, Porto Rico, July 6, 1925.

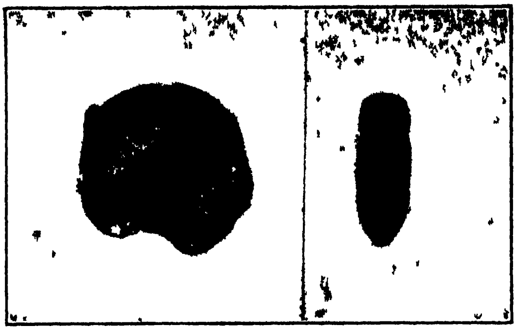

FIG. 6.—*Eupelmus saissetiae*; (*a*) full-grown larva *in situ*; (*b*) pupa, greatly enlarged

Lecaniobius cockerelli Ashmead

(1896 Proc. Ent. Soc. Wash., vol. 4, p. 17)

A number of specimens were reared from *Saissetia oleae* on avocado at Río Piedras, May 26, 1925.

Eupelmus saissetiae Silvestri

(1915 Bol. Lab. Zool. Agr. Portici, vol. 9, p. 289)

The Black Scale, *Saissetia oleae*, is held in partial check in Porto Rico by parasites and apparently *Eupelmus saissetiae* is rather abundant. On June 11, 1925, many mature scales were found to contain grubs in various stages of development, one to a scale, the full-grown grub measuring 3.75 mm. A number were removed from the scale coverings and placed in a vial without food and pupated on June 13th.

Shortly afterwards the adults issued, showing a great variation in size, due most likely to the cutting short of their food supply.

Pseudoteroptrix imitatrix Fullaway
(1918 Proc. Haw. Ent. Soc., vol. 3, p. 464)

A single specimen reared by the writer from the mining scale, *Howardia biclavis,* on Acalypha at Río Piedras, November 24, 1924, has been determined by Mr. Gahan as this species. It is recorded as an abundant parasite of *Howardia biclavis* in Hawaii but out of a large amount of material placed in parasite cages in Porto Rico only the single specimen was obtained.

Plagiomerus cyanea (Ashm)
(1886 Entomologica Americana, IV, p. 156, *Comys*)

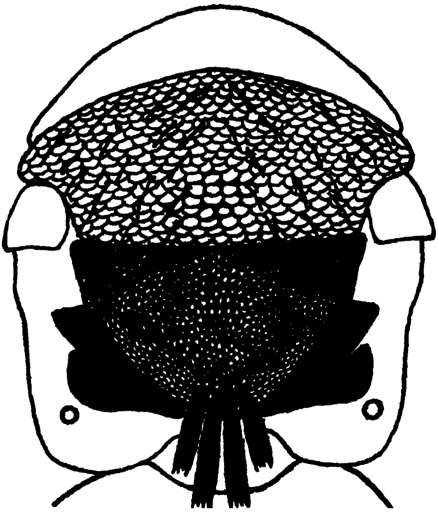

FIG. 7.—Thorax of *Plagiomerus cyanea* greatly enlarged, showing the flattened scales

This species is easily placed generically by the four-jointed funicle and the cluster of flattened scales at the apex of scutellum. One species of the genus, *P. diaspidis,* was reared in New Mexico from *Diaspis cacti,* and Girault (Ann. Ent. Soc. Amer., Vol. VIII, p. 280) stated that *Comys cyanea* Ashmead from Florida should be placed in *Plagiomerus* and is very much like *diaspidis* but has joints three and four of the funicle white. Mr. P. H. Timberlake, to whom the writer sent his material for study, writes that "it differs from the described species *diaspidis* Cwfd., *cyanea* (Ashm.) and *hospes* (Timb.) in having the scale-like setae extremely broad and also from *cyanea* in having the mesonotum much less brilliantly blue, and its pubescence dark instead of white." After considerable study and comparison with the type of *Comys cyanea,* Mr. Gahan and the writer decided that this material is most probably *cyanea* Ashmead. The type of *cyanea* from Florida is card-point mounted and the relative width of the scale-like setae is difficult to discern although they appear slightly narrower than in the Porto Rican material.

Female: Antennae nine-jointed, the pedicel longer than the first two funicle joints together; the funicle four-jointed, its second joint distinctly shorter than the others and only half as long as wide; hairs prominent. In slide-mounted specimens the scutellum is deeply and roundy reticulated, the mesonotum more coarsely and less distinctly so; from base of scutellar fold apex, arise a cluster of much-flattened, very broad scales and just above the fold on each side is an oblique row of three prominent setae. Mesonotum with rather long black setae. Wings hyaline, strongly iridescent, densely and finely ciliated over apical half, the hairless oblique streak very difficult to distinguish on account of the fineness and sparseness of cilia over the basal area; submarginal vein with seven prominent setae; marginal vein not punctiform, and the post-marginal short but distinct. Ovipositor very deeply seated, but with a short portion extending beyond abdomen.

Head and body blackish with decided metallic bluish-green reflections. Specimens mounted in balsam on slides show dark-brown. Antennae are pale yellowish, most of the pedicel, the first two funicle joints, and most of the first and last joint of the club, fuscous. Legs blackish, with following exceptions: the knees and apices of the front tibiae, basal half and apices of the middle femora and base and apical half of middle tibiae, the base and apices of the hind tibiae, and all tarsi, pale. The brown portions of the legs show coarse reticulation under high power.

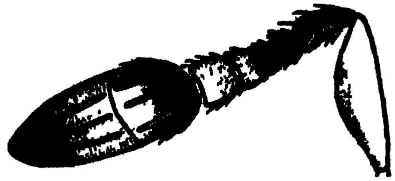

FIG. 8.—Antenna of female *Plagiomerus cyanea* (Ashm.)

Length, .80–.90 mm.

Re-described from a series of card-point-mounted females and four individually slide-mounted females, all reared by the writer during June and July, 1925, from lignum vitae, infested with *Ceroplastes cirripediformis, Aspidiotus cyanophylli,* and *Aleurothrixus howardi,* collected at Central Aguirre, Porto Rico. Without very much question this species is a primary parasite of the wax scale.

THE GENUS *Aspidiotiphagus* Howard

This genus has been recently revised by the Italian Entomologist, Guido Paoli (Bol. della Soz. Ent. Italiana, Vol. 58, July 1926), and he now recognizes as valid two species and one variety, *citrinus* var. *agilior* Berl. Ashmead's *A. aleyrodis* as represented in the U. S. National Museum by three pin-mounted specimens is not an *Aspidiotiphagus* but is probably an *Encarsia.* Heretofore *A. lounsburyi* has been known only from the Island of Madera, and Liguria, Italy, where at the latter place it was introduced and established as a parasite of *Chrysomphalus dictyospermi.* It is therefore of interest to record the presence of this species in the New World. Specimens of both typical *citrinus* and *lounsburyi* were submitted to Dr. Paoli who checked on the identification.

KEY TO SPECIES OF *Aspidiotiphagus*

First joint of club distinctly shorter than either of the apical two, submarginal vein always with a single seta, marginal setae 3-4........................ *lounsburgi* Berl. and Paoli.

First joint of club nearly as long as each of the apical two, submarginal vein with two setae, marginal setae 4-6..... .*citrinus* (Craw.)

Aspidiotiphagus citrinus (Craw.)

(1891 Destructive Insects, Sacramento, Cal.; *Cocoophagus*)

The writer has examined in the U. S. National Museum slides containing specimens reared from *Aspidiotus aurantii* at San Francisco, Cal., April 1902, by Alex Craw. Without the original types, which are apparently lost, this material must be considered as typical and as authoritative as any. These specimens show nearly the entire adomen darkened and not distinctly banded as in the familiar drawing that has served to illustrate this species for so many years. They show the first joint of the club almost as long as either of the apical two, the submarginal vein always with two setae and the number of setae on edge of the marginal vein varying from four to five, the latter number being the rule.

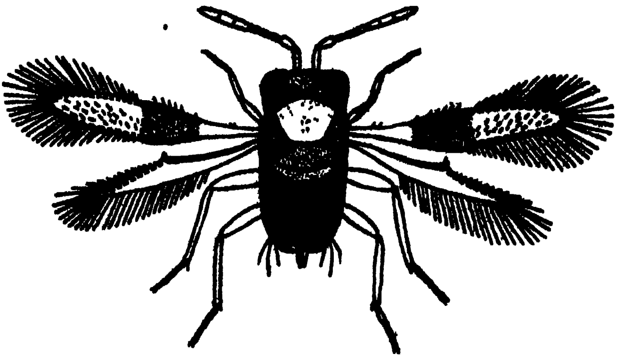

FIG. 9.—Adult of *Aspidiotiphagus citrinus* (Craw.)

Female: Head as wide as thorax; antennae eight-jointed, the scape long and fusiform; club elongate, the last two joints subequal and only slightly longer than the first, and miscroscopic elevations present as in figure; eyes large and prominent. Scutellum with two rather distinct pores. Forewings are rather wide and the anterior margin well-rounded; the marginal vein is furnished with four to five marginal setae, that number being variable, often a specimen having four marginal setae on one wing and five on the other; the submarginal vein, however, always has two fine setae; the disc of the forewing with numerous cilia arranged in three or four more or less distinguishable rows and there is a bare area about the stigma.

Head and body brown with the exception of the vertex, lower two-thirds of mesonotum and the parapsides, all of which are yellowish. Antennae uniform smoky. Anterior wings with the marginal vein dusky, and with dark infumation or clouding beneath its length, extending across the entire width of wing. Legs pale yellowish.

Length of body, .36–.44 mm.; expanse, .920–1 bb.; greatest width of forewings, .08–.10 mm.;

Male unknown.

The above description is drawn up from numerous slide-mounted and fresh specimens reared from *Asterolecanium pustulans* on various hosts during 1925 at Río Piedras, Porto Rico; from *Diaspis carueli* on juniper, Newark, Delaware, October 16, 1925; and from *Chrysomphalus tenebricosus* on willow at New Orleans, La., February 11, 1926.

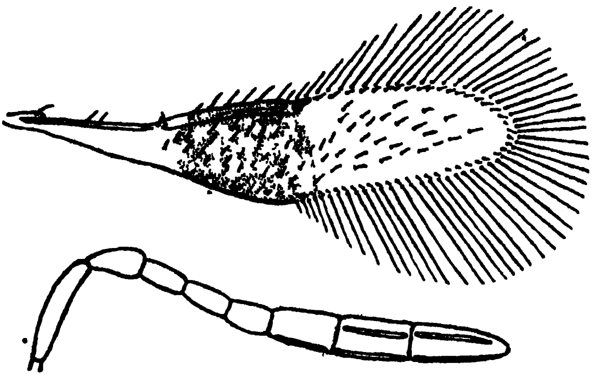

FIG. 10.—Forewing and antenna of *Aspidiotiphagus citrinus* (Craw.)

Aspidiotiphagus lounsburyi

(1916 Redia, XI, fasicle 1, p. 305, *Prospaltella*)

Readily distinguished from *Aspidiotiphagus citrinus* by its more yellowish color, the first joint of the club being only about half the length of the second joint, and especially by having only a single seta on submarginal vein.

Female: Head as wide as thorax, the eyes large and prominent. Antennae eigth-jointed, long and slender, especially the fusiform scape; pedicel distinctly larger and wider than the funicle joints which are all subequal in length; first joint of club only about half as long as the second and of equal width. Ocelli placed in equilateral triangle. Forewings long and narrow, narrower and more pointed at tip than those of *A. citrinus;* marginal cilia very long, those on hind margin distinctly longer than those on anterior margin; the marginal vein furnished with three marginal setae, although some have four and there is a single submarginal vein seta.

The entire head and body is of a dirty yellow color, the posterior two-thirds of the mesonotum and the parapsides being the lightest in coloration. Some specimens are much darker, approaching more the coloration of *citrinus.* Eyes dark reddish brown. Ocelli distinctly carmine red. Antennae dirty yellowish. Forewings with infuscation across the width of the wing beneath the marginal vein similar to *citrinus.* The cilia on disc are fewer than in *citrinus* and arranged in two or three rows. Legs pale.

Male unknown.

Length, .30–.36 mm.; expanse, .68–.80 mm.; greatest width of forewing, .06 mm.

Above description made from a slide containing seven females and a slide containing four females reared by the writer from *Aspidiotus destructor* on plant at Río Piedras, Porto Rico, May 29, 1925; and four females on slide reared from scale material on citrus, Río Piedras, Porto Rico, May 21, 1925; six females on slide reared from *Diaspis pentagona* on mulberry June 5, 1925, at Río Piedras, Porto Rico. The writer has for comparison many specimens from the Island of Madera, reared from *Chrysomphalus dictyospermi* by Guido Paoli, June 1923.

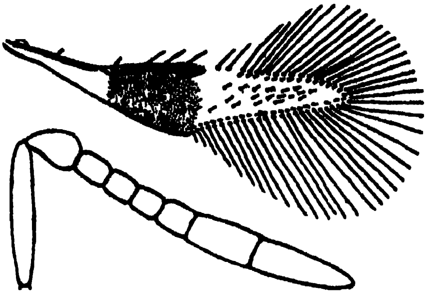

FIG 11.—Forewing and antenna of *Aspidiotiphagus lounsburyi* **Berl. and Paoli**

NOTES ON PORTO RICAN THYSANOPTERA

By H. L. Dozier[1]

The writer is greatly indebted to Dr. J. D. Hood who has kindly confirmed or determined the species recorded in this short paper.

Franklinothrips vespiformis (Crawford)

Ten adults taken on guava foliage in association with *Selenothrips rubrocinctus* and the guava whitefly, *Aleurodicus minimus*, September 21, 1924, at Río Piedras. Also collected in bloom of cultivated rose May 24, 1925.

Aleurodothrips fasciapennis Franklin

From citrus material infested with Soft and Purple Scale, May 24, 1925, at Río Piedras.

Selenothrips rubrocinctus (Giard)

This species was present in the adult and last instar in large numbers September 18, 1924, attacking the underside of foliage of a muscadine grape imported from Florida on the experimental grape plot at the Station. While serious damage was done to the muscadine, other varieties adjacent were not attacked, including the native grape, Californian varieties, *Vitis amurensis* and the Carmen. On October 28th, this thrip was abundant on an imported variety of mango, on guava, and on almendra, *Terminalia catappa.* On No-

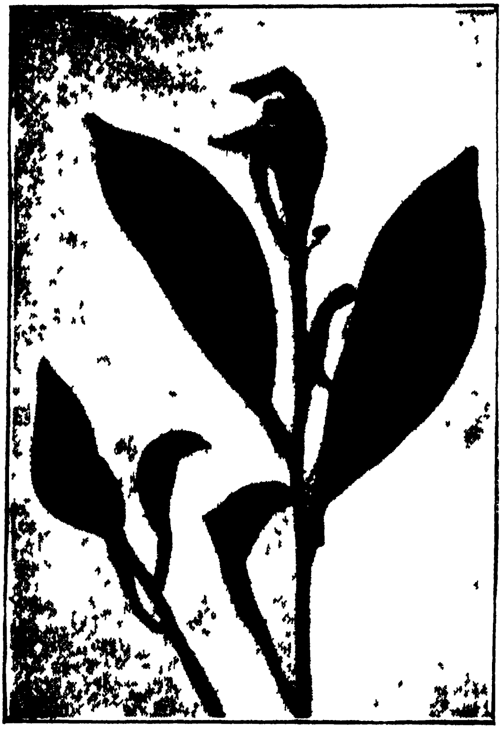

FIG. 1.—Typical work of the Cuban Laurel Thrips, *Gynaikothrips uzeli*, on "Laurel de India"

vember 1st it was found attacking young leaves of the mangosteen, *Garcinia mangostana,* and on the 5th the Burbank Thornless Blackberry in the berry plots was extremely badly infested and nearly completely defoliated. The Himalaya Raspberry, *Rubus ellipticus,* was also generally attacked and the Cuthbert Raspberry was very slightly infested. The native berry was not attacked.

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[1] Formerly Chief Entomologist of the Insular Experiment Station

Gynaikothrips uzeli (Zimm.)

At all seasons of the year this thrips may be found abundant, curling the leaves and growing tips of the "Laurel de India", *Ficus nitida* Thunb., wherever the latter occurs on the Island. Two predaceous anthocorid sucking bugs, *Macrotracheliella nigra* Parshley and *Cardiostethus* sp., were attacking this thrip in abundant numbers at Juana Díaz, February 11, 1925. Trees at San Juan were found heavily infested July 2, 1925.

Heliothrips haemorrhoidalis Bouche

Abundant breeding on leaves of an introduced plant, *Barringtonia speciosa,* at Río Piedras, May 24, 1925.

Frankliniella insularis (Franklin)

This is the most common species of flower thrips over the Island, attacking many different flowers—in blooms of *Canavali maritimus* on the beach at Santurce, January 6, 1925; abundant in blooms of "granadilla", *Passiflora quadrangularis,* June 17, 1925; in rose blooms at Río Piedras, May 24, 1925.

Frankliniella triciti (Fitch)

Taken in blooms of grape fruit at Trujillo Alto.

Haplothrips merrilli Watson

Specimens of what has been placed dubiously as this species have been obtained from parasite emergence boxes of scale and whitefly material as follows: numerous specimens from *Asterolecanium bambusae* material on bamboo, Río Piedras, May 31, 1925; one specimen from *Pulvinaria iceryi* material on sugar cane at Arecibo, May 31, 1925; one specimen from *Howardia biclavis* on Acalypha, Río Piedras, May 31, 1925; one specimen from *Ceroplastes cirripediformis* on passion vine; and a single specimen from *Aleurothrixus howardi* on lignum-vitae at Central Aguirre, July 22, 1925. The fact that this thrips has been reared in each case associated with either scale or whitefly material would indicate that the species is most likely predaceous on the young.

Hoplandrothrips reynei Priesner

Several specimens of this large thrips issued from *Asterolecanium pustulans* material on *Cassia fistula* placed in parasite emergence cages, May 31, 1925, at Río Piedras. This species also is most probably predaceous on young scale and whitefly.

EDIBLE GARCINIAS AND POSSIBLE MANGOSTEEN STOCKS [1]

By P. J. WESTER

PRELIMINARY REMARKS

The genus *Garcinia* includes some 210 or more species, mostly described from tropical Africa and the Indo-Malayan region, including New Guinea and the Philippines, which last-mentioned archipelago has 30 known species. In the south and east of the Malay Archipelago the range of the genus extends to Australia, whence four species have been described, to New Caledonia which has contributed 12, and to Fiji with four species of which one also has been found in the Tonga Islands, the eastern limit of the genus. The northermost limit for these plants is Hongkong, where two species have been found. To the westward 16 species of *Garcinia* have been described from Madagascar, and 80 from tropical continental Africa where they are scattered from coast to coast. Five species of *Garcinia* previously described from tropical America are now referred to other genera.

Most species of *Garcinia* perhaps prefer a moist climate throughout the year, though many also thrive in regions with pronounced dry seasons. While the vast majority grow at low and medium elevations, some are also found at altitudes ranging from 1,300 to 2,000 meters.

Practically all *Garcinias* are trees, some of which are reported to attain a height of 20 or more meters. A few are shrubs, while at least two climbers have been described. The habit of a considerable number is still unknown.

The leaves are opposite, rarely ternate, simple, thick and leathery, or thin. The flowers are polygamous or dioecious, solitary or in fascicles, terminal or axillary, with four to five sepals and petals, many stamens in the male flowers, and a one- to many-celled ovary.

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[1] The success recently attained in grafting the mangosteen on the *Bunag* has prompted a review of the experiments made to find a stock for the mangosteen, and the literature related to *Garcinias*, in an attempt to determine in view of past experiences what other species might be sufficiently closely related to the mangosteen to be worth experimenting with for stock purposes, and to assemble for the convenience of experimenters with these interesting plants the information available about species with edible fruits, hitherto widely scattered in many publications difficult of access. Incidentally the paper also serves to call attention to the lack of detailed knowledge relative to the habitat, climatic requirements, and the fruits of many species with alimentary potentialities. It is a pleasure to acknowledge my obligations to Governor Carl M. Moore of Sulu, for herbarium material of *G. mooreana*, and to Dr. S. Youngberg and Mr. A. W. Prautch, Bureau of Agriculture, Manila, P. I., who furnished the photographs for the accompanying plates.

The mangosteen is the best known species in the genus, and one of the most highly prized fruits in the world. Indeed, a suggestion for improvement of this excellent fruit is a tax on the imagination. Not only is the snowwhite flesh exquisitely flavored, and very attractive to the eye contrasted against the pink lining of the rind as the fruit is opened, but it is provided with a thick, fibrous shell or container for protection that makes the fruit a better shipper than most tropical fruits. And yet, hasn't some one said that there is a fly in every ointment, or words to that effect?

An aristocrat among fruits, the mangosteen tree is, one might say, highly temperamental, fastidious in its environmenal requirements, and difficult to handle in the nursery. It thrives only in a hot, moist climate, with fairly abundant rainfall of equal distribution throughout the year. The seeds are perishable and rapidly lose their viability unless properly cared for. The plant has a weak root system and is of very slow growth in the nursery stage. Hence the mangosteen, notwithstanding its excellence, has never become widely distributed, and still is grown to any considerable extent only within a restricted area in Java and the Malay peninsula, with small orchards in Burma, Siam, Indo-China, and Ceylon. It is rarely seen in the western Indian peninsula. Semi-cultivated it occurs in Jolo, in the Sulu Archipelago, Philippine Islands, where it thrives to perfection. Less than a score of trees are in bearing in all the other islands of that Archipelago though the climatic conditions are favorable in many districts. Occasional trees have fruited in Hawaii, Ecuador, and the West Indies, including Porto Rico, but all attempts at a general dissemination of the mangosteen have failed.

EXPERIMENTS WITH GRAFTING AND STOCKS

In the Western Hemisphere the mangosteen first fruited in 1875 in Trinidad, B. W. I. After many fruitless attempts to raise plants from the seeds had been made, the late W. H. Hart, then superintendent of the Botanic Garden of that island, as early as 1888 tried to inarch the mangosteen on other, more vigorous and fast-growing species of *Garcinia* but without success. His experiments were repeated in Jamaica with the same results. Through the initiative of Dr. David Fairchild, agricultural explorer in charge of foreign seed and plant introduction of the Bureau of Plant Industry, United States Department of Agriculture, experiments in inarching the mangosteen on other species of *Garcinia* and related plants were begun about 1902 by the late G. W. Oliver, and later have been continued by Mr. Edward Goucher, now superintendent of the Bell Plant Introduction Station, Glen Dale, Md. As a result of his work Oliver in 1910 published a bulletin in which he claimed to have found certain species successful stocks for the mangosteen. To quote:

> "The most promising species of *Garcinia* for use as stock plants for the mangosteen are *G. tinctoria*, *G. morella*, and *G. livingstonei* in the order named. *Platonia insignis*, so far as the work has progressed, is a very promising stock from one to three years after germination, and if it will grow under the conditions suitable for the mangosteen it may turn out to be the best stock of all those tried."

Aside from those mentioned, Oliver says he experimented with about 20 species, among which he mentions *G. cornea*, *G. hanburyi*, *G. fusca*, *G. loureiri*, *G. sizygifolia*, *G. speciosa*, *G. spicata*, *Calophyllum calaba*, and *C. inophyllum*. However, while there were no difficulties in getting a union between stock and scion, later it was found that after it had been severed from its own roots the mangosteen refused to accept the stock though in some instances it remained alive for a year after severance. In the moist greenhouse atmosphere the stumps of such grafted mangosteen scions frequently developed aerial roots that descended into the soil and re-established their own root systems.

Experiments made by the writer more than ten years ago at the Lamao Experiment Station, Philippine Islands, showed that *Calophyllum inophyllum* could easily be shield-budded. Shield buds of the mangosteen inserted on this plant and on *G. venulosa* made a good union, and the buds remained alive for some three months before they died. Cleft grafts of mangosteen on *G. dulcis* and *G. binukao* likewise failed, though the former species was shield-budded on itself, and the latter cleft-grafted on itself without difficulty.

In 1918 in Parang, Jolo, Sulu Archipelago, and in Iwahig, Palawan, Philippine Islands, I came across a *Garcinia* called Bunag[1] (in Palawan) that had the characteristic features of the mangosteen except that the fruit was smaller, reddish instead of purplish, with sharply acid instead of subacid flesh like the mangosteen. In fact, it was so similar to the mangosteen that it occurred to me that here was the long-sought-for stock for the mangosteen, if it existed. Seeds

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[1] From material brought him, Mr. E. D. Merrill, then botanist of the Bureau of Science, Manila, P. I., identified the Bunag as *G. benthami* Pierre, under which name it is described and figured in Bulletin No. 89, The Food Plants of the Philippines. However, from the description and plate of *G. Benthami* in Flore Forestiere de Indo-China by Pierre. it would appear that *Bunag* is not that species.

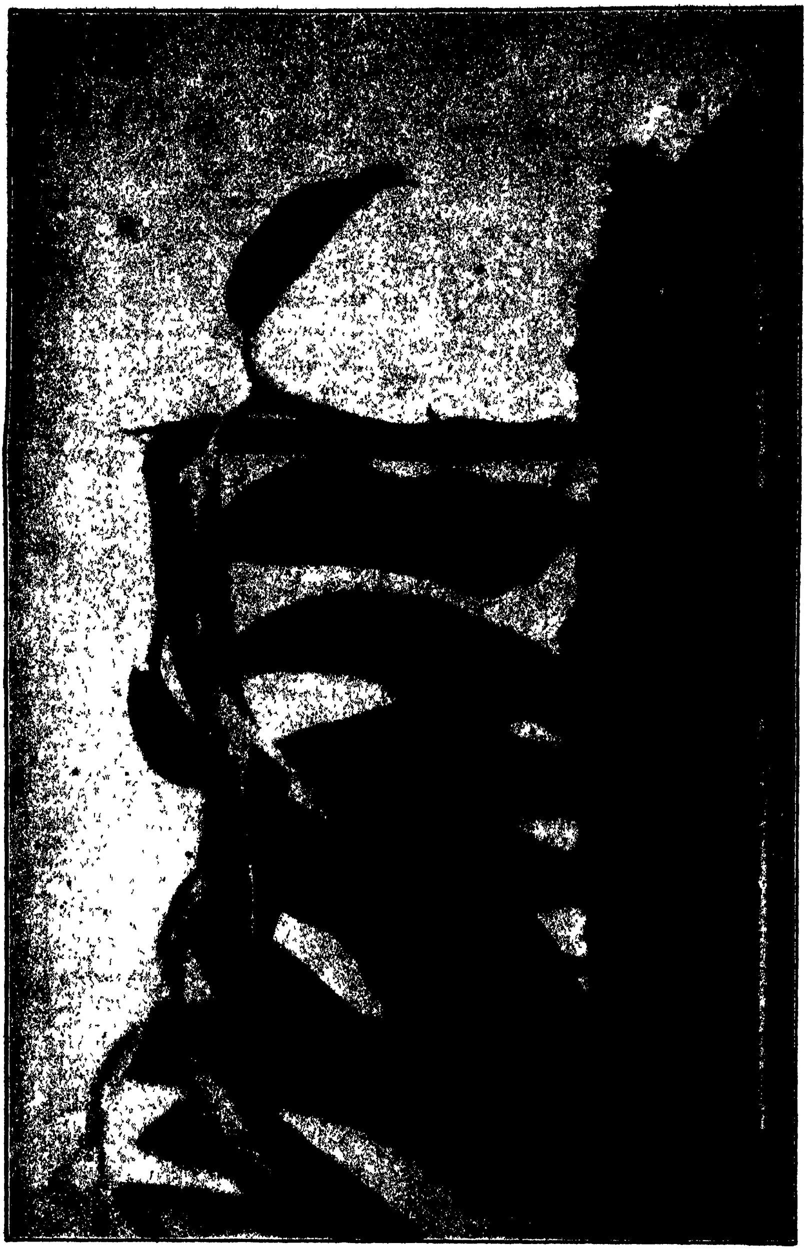

FIG. 1.—A shield-budded plant of Banati, *Garcinia dulcis*, related to the mangosteen. Experiments made at the Lamao Experiment Station, P. I., show that plants of this family are easily shield-budded and cleft-grafted.

were accordingly obtained from Palawan and propagated by the Bureau of Agriculture at the Lamao Experiment Station with the idea of trying the plants as stocks for the mangosteen. However, owing to the frequent changes of superintendents of the Station, the purpose for which the Bunag plants were grown was lost sight of, and nearly all were distributed as they grew up. One plant found its way to the garden of Mrs. R. M. McCrory, Manila, where quite by accident I came across it in 1923, when it had grown into a small handsome tree. A dozen or so shield buds of the mangosteen were inserted in the top of the tree, most of which made a good union. But the tree was such a handsome one that, not knowing whether or not the buds would make a successful growth, I hesitated to cut back the top sufficiently to force the buds into growth, and they finally died. In the meantime a few *Bunag* plants were obtained by Mr. John R. Schultz, Calauan, Laguna, and in May, 1924, I inarched a small mangosteen plant on one of the *Bunag* seedlings, which rapidly made a good union. Fig. 2 shows the grafted plant about two years after the inarch was made. It was then nearly a meter high, and in perfect condition.

While the *Bunag* grows wild in localities with an evenly distributed rainfall, in Manila it has shown itself well adapted to a climate having a long, dry season. The tree shown in Fig. 3 is about 5 years old from planting the seed. Of course, the outcome is by no means certain, but from present indications the *Bunag* used as a stock for this fruit promises to hasten by several years the coming into bearing of the mangosteen as compared with its being grown on its own roots, and to extend the culture thereof over vast regions where hitherto this has been impossible for climatic reasons.

POSSIBLE STOCKS FOR THE MANGOSTEEN

From the experience gained in previous experiments it is apparent that only rather close relatives are acceptable as stocks by the mangosteen, and the theory is advanced that the position of the flowers, whether terminal or axillary, and the character of the pericarp, whether fibrous and crustaceous or fleshy, indicate the species that are sufficiently closely related to the mangosteen to be worth trying for stock, and those others that are so far removed from this fruit that a successful union of the two is beyond probabilities.

Trees with fruits having a fibrous, crustaceous or shell-like, inedible pericarp are believed to be most likely to prove successful stocks. Except in the *Bunag* whose flowers are unknown, this character is always associated with terminal flowers. To this group

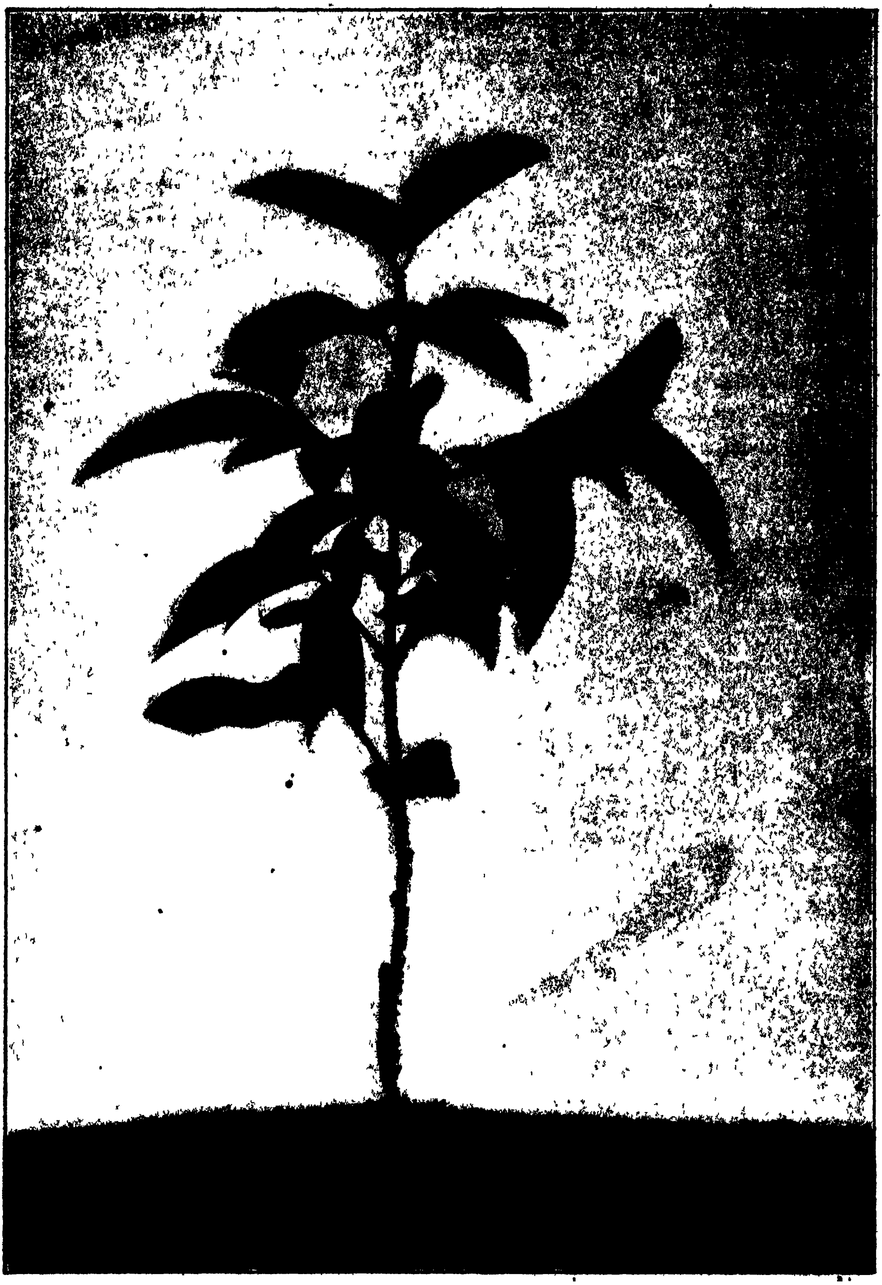

FIG. 2.—Mangosteen successfully grafted on another plant, the Bunag. This is of vigorous growth and thrives under climatic conditions under which the mangosteen fails to grow.

belong the mangosteen, *G. hombroniana,* and *G. penangiana.* Apparently *G. cornea* and *G. celebica* also have fruit characters in common with the mangosteen, for Roxburgh describes the fruit of the former as "covered with a dark purple, juiceless bark," and Heyne says of the fruit of the latter that it is similar to the mangosteen. Undoubtedly there must be other species belonging in this group among the large number of which the descriptions are so incomplete that they fail to convey a definite idea of the fruit character, and another large number of which the fruit is still unknown. Two other species particularly worth investigation are *G. delpyana,* said to have a fruit with spongy pericarp—an expression sometimes used about the mangosteen—and *G. dioica,* said to have a fruit like the mangosteen. Both species are described as having terminal as well as axillary flowers.

A little further removed from the mangosteen are those species bearing terminal flowers, but with fruits having a more or less fleshy, frequently edible pericarp. Until more is known of their behavior it is believed that they should be considered possible stocks for the mangosteen. Those with inedible or little-known fruits belonging in these two groups will presently be enumerated. Species that belong in this class having edible fruits are included in the list of edible *Garcinias.*

Still more remote from the mangosteen is a third group of species in which the flowers are produced in the axils of the leaves as well as at the end of the twigs. With perhaps rare exceptions they are believed not sufficiently closely related to the mangosteen to afford material for stock. Finally, there is a fourth group in which all flowers are axillary. All of the several species in this group that have been tried for stocks have failed, and it seems improbable that it will yield stocks for the mangosteen.

In the following species the flowers are terminal, and fruits have been collected, but as will be noted, the descriptions thereof are too incomplete to furnish clues as to whether or not the pericarp is crustaceous. Most fruits, if not all, probably are inedible. The plants are suggested for trial as mangosteen sto[illegible]

Garcinia echinocarpa Thw.

A tree 12 to 15 meters high, native of Ceylon, where it is found up to an elevation of 1,800 meters; therefore, some forms are likely to be quite cold-resistant, a valuable feature under Florida conditions. The leaves are 7.5 to 15 cm. long, lanceolate-oblong or obovate, acute or retuse, thick and leathery. The flowers are pale

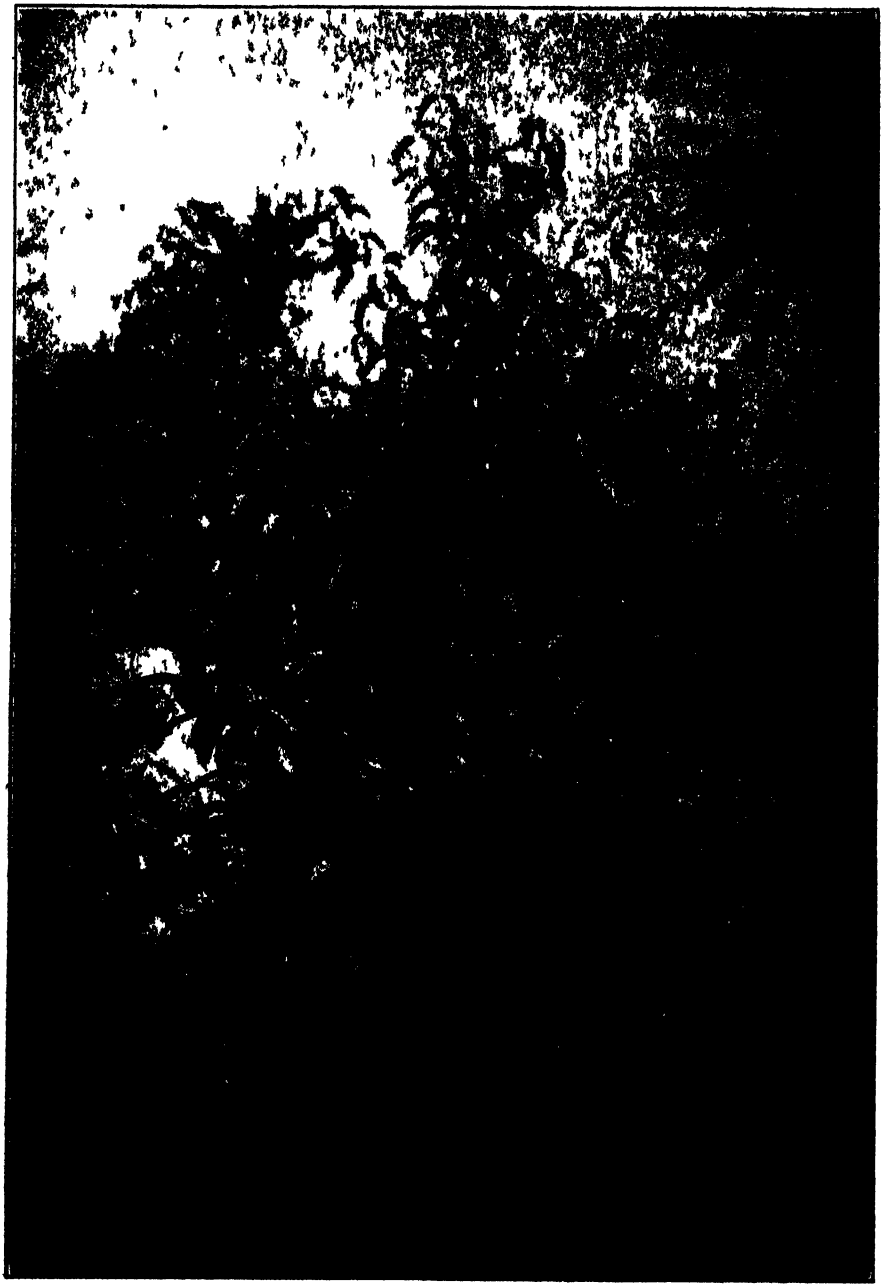

FIG. 3.—Bunag seedling in Manila about five years old, showing its vigor and adaptability to climatic conditions unendurable to the mangosteen.

yellow, the male sometimes axillary, but the female terminal and solitary. The fruit is 4 cm. long, subglobose, the surface dark red and covered with short, broad protuberances somewhat like *Litchi chinensis.*

G. latissima Miq.

A plant found in Celebes and Halmahera. The leaves are 30 cm. long and 16 cm. broad, and leathery. The fruit is subglobose, 4 to 6 cm. in diameter, with a fleshy pericarp and white pulp, containing one seed. The habit of the plant is unknown, but judging from the large leaves it is of robust growth.

C. maingayi Hook. f.

A tree 12 to 18 meters tall, native of the Malay Peninsula. The young branches are thick and 4-angled. The leaves are elliptic-oblong, obtuse, shining on both sides, 11 to 17 cm. long and up to 8 cm. wide. The flowers are waxy white. The fruit is roundish, 5 to 6 cm. in diameter, 4 to 6-celled.

G. microstigma Kz.

A shrub about two meters tall, native of the Andamans. The leaves are elliptic to elliptic-oblong or lanceolate, subacute, up to 10 cm. long. The female flowers are solitary. The fruit is roundish, up to 5 cm. across; the pericarp smooth, red and thin; the pulp containing 2 or more seeds.

G. montana Ridl.

A small tree 5 meters tall, found at an elevation of 900 meters on Mt. Ophir, Malay Peninsula. The leaves are lanceolate, bluntly acuminate, and thickly coriaceous. The female flowers are solitary, greenish yellow. The fruit is flask-shaped and beaked, 2 cm. long.

G. multiflora Champ.

A shrub, native of Hongkong. The leaves are obovate, obtuse, up to 7 cm. long, and 3 cm. wide. The fruit is subglobose, smooth, 2.5 cm. in diameter, 1 to 2-seeded, the seeds being similar to those of the mangosteen. The plant is probably quite cold-resistant.

G. schefferi Pierre

A tree 10 to 15 meters high, native of Indo-China. The leaves are oblong or elliptic, rounded to short acuminate, leathery, 8 to 13 cm. long, and 3 to 6 cm. broad. The female flowers are solitary. The fruit is oval, about 3 or more cm. long, smooth, ripening in September.

G. travancorica Bedd.

A very attractive tree of medium size, found in Travancore, India, at elevations from 900 to 1,500 meters. The leaves are narrow-oblong to sub-spatulate, obtuse, dark green and shining, up to 10 cm. long. The female flowers are solitary. The fruit is inedible. The plant is probably quite cold-resistant.

In the following species the fruit is not known, but they have terminal flowers and therefore are believed to be worth while experimenting with as stocks for the mangosteen:

Garcinia baillonii Pierre. Borneo
Garcinia bassacensis Pierre. Indo-China
Garcinia crassiflora Jum. & Perr. Madagascar
Garcinia gracilis Pierre. Indo-China
Garcinia krawang Pierre. Borneo
Garcinia kurzii Pierre. Andaman Islands
Garcinia lucens Pierre. Borneo
Garcinia madagascariensis Baill. Madagascar
Garcinia multibracteolata M. Philippines
Garcinia mungotia Pierre. New Caledonia
Garcinia murdochii Ridl. Borneo
Garcinia nitida Pierre. Borneo
Garcinia pancheri Pierre. New Caledonia
Garcinia quadrifaria H. Bu. Tropical West Africa
Garcinia riedeliana Pierre. Celebes
Garcinia sorsogonensis Elm. Philippines
Garcinia trianii Pierre. Borneo

The fruits are unknown, but botanists who have examined other parts of the plants regard *G. malaccensis* Hook. f., from the Malay Peninsula; *G. speciosa* Wall., from Burma and the Andamans; *G. wichmannii* Lbch., from New Guinea; *G. melleri* Baker, and G. *pauciflora* Baker, both from Madagascar; and *G. vieillardii* Pierre, from New Caledonia, as being very closely related to the mangosteen, and so are in line for trial for stocks for this fruit.

EDIBLE GARCINIAS

The mangosteen is by far the most important fruit in the genus, but there is a large number of species the fruits of which are eaten by the inhabitants of the countries where they grow, several of which have been domesticated, and are cultivated to some extent by the natives. The remarks relative to the edible qualities of a number of the fruits in addition to the descriptions of the plants by various botanists would indicate that they are worthy of more attention than has been accorded them. To the plant breeder they present a large virgin field of more than ordinary interest. Not a few have terminal flowers, of which some, at least, may be found to be good stocks for the mangosteen.

G. afzelii Engl.

A plant of unknown habit, found in Guinea and Sierra Leone. The leaves are oblong-elliptic, acuminate, and rather thin. The fruit is roundish, 1.5 cm. or more in diameter, smooth, yellow, and edible.

G. atroviridis Griff. ASAM GELUGUR

A wild and cultivated very graceful tree with pendulous branches attaining a height of 10 to 18 meters, native of the Malay Peninsula, where it is found from sea level up to 500 meters altitude. The leaves are 15 to 23 cm. long, and 5 to 7 cm. wide, oblong-lanceolate, abruptly acuminate, bright pink when young changing to dark green, shining on both sides. The flowers are terminal, the female solitary, large, and blood red. The fruit is sub-globose, 7.5 cm. or more long, orange yellow, smooth, with a firm-textured but not tough, fleshy, acid pericarp, enclosing the rather thin translucent pulp, divided into 9 or 10 locules. Too acid to eat out of hand, stewed with sugar the fruit is excellent according to H. N. Ridley, for many years director of the Botanic Garden in Singapore, who says that it is the best soft-rinded *Garcinia* in the Malay Peninsula.

G. bancana Miq. KELABANG

A tree, 10 to 20 or more meters high, native of wet swampy forests in Banka, Sumatra, and the Malay Peninsula. The leaves are broadly obovate-lanceolate, rounded to mucronulate, 12 to 20 cm. long, the petiole winged. The flowers are axillary. The fruit is ovoid, green, and fleshy, and is eaten by the natives in the Dutch possessions.

G. benthami Pierre. BOI

A tree 20 to 25 meters tall, with pyramidal crown, native of Indo-China. The leaves are oblong or elliptic-oblong to lanceolate, short acuminate to obtuse, up to 13 cm. long in old, and up to 18 cm. long in young trees. The flowers are terminal, yellow, the female solitary. The fruit is about 4.5 cm. in diameter, obpyriform, smooth; the persistent style concave, and tiara-shaped; the pulp in which the 5 to 10 seeds are embedded is white, acid, and of agreeable taste. The fruit ripens in April. The tree should be tried as a mangosteen stock.

G. binucao Cy. BINUKAO

A tree 15 or more meters tall, with drooping branches, of wide distribution under varying climatic conditions at low elevations in the Philippines, succeeding well where the dry season is pronounced. The leaves are obovate to elliptical, pointed, smooth and leathery, 5 to 12 or more cm. long. The flowers are axillary. The fruit is about 4 cm. in diameter, subrotund, flattened at the apex, sometimes nippled at the base, smooth, greenish yellow. The pericarp is quite firm, but like the scant pulp fleshy and very acid, and is eaten with fish by the natives. The 6 to 8 seeds are enclosed in bony shells. The fruit ripens in May and June. The binukao has been sucessfully introduced and fruited in Miami, Florida.

G. cambogia Desr. HILA ARADAL

A small, erect, handsome tree with drooping branches, native of the lowlands up to an elevation of 600 meters in Ceylon and western India. The leaves are 5 to 12 cm. long, oblong-elliptic or lanceolate, rather thin, dark green and shining. The male flowers are axillary, the perfect ones sometimes terminal. The fruit is about the size of an apple, the basal half with 6 to 8 grooves lengthwise, the apex flat and depressed and the surface yellowish or reddish. The pericarp is fleshy, and together with the 6- to 8-celled pulp of pleasant flavor, and eaten as a substitute for tamarinds with fish. The Singalese also dry the fruit and use it for flavoring curry. The fruit ripens in June and July.

G. celebica L. KIRASA

A rather rare tree up to 15 meters high, native of the Malay Archipelago at low elevations where it occurs wild and cultivated. The leaves are elliptic to oblong-elliptic, rounded, shining, and up to 22 cm. long. The flowers are terminal. The fruit is roundish, somewhat flattened, in the cultivated forms up to 5 cm. in diameter. While the descriptions do not refer to the character of the pericarp, the fruit is said to be similar to the mangosteen, though with less, rather acid, white edible flesh, 5- to 6-celled. It ripens in June and July. The tree should be tried as a stock for the mangosteen.

G cochinchinensis Cy.

A handsome tree with erect trunk, native of Indo-China, where it is cultivated. The leaves are ovate-oblong and subacute. The flowers are axillary. The fruit is subglobose, 5 cm. across, reddish yellow, 6-locular, fleshy, acid and edible.

conrauana Engl. Nfu

A tree 20 to 30 meters in height, native of Kamerun. The leaves are elliptic, leathery, up to 9 cm. long. The fruit is 3 cm. in diameter, subglobose, reddish yellow, with orange-colored edible pulp. The seeds also are edible. The fruit ripens in June.

G. cornea L. Hussur

Originally described from the Malay Archipelago, this plant also has been collected in Burma. According to Roxburgh who described it from trees obtained from the Malay Islands, growing in Calcutta, it is a handsome tree, in Burma attaining a height of 18 meters. The leaves are oblong, short acuminate, shining, 10 to 15 cm. long. The flowers are terminal, pale yellow. The fruit is nearly round, about 3.5 cm. in diameter, covered with dark purple, juiceless bark, the seeds up to 4, embedded in white, subacid pulp of pleasant taste. The fruit ripens in May and June. Hooker remarks that the pericarp is spongy as in the mangosteen, bright red in color, and that the pulp is very acid. Therefore, notwithstanding the failure reported by Oliver it is believed that the Hussur should be tried again as a stock for the mangosteen. The species is considered a synonym of *G. celebica* by some authors.

G. costata Hemsl.

A rather large tree, sometimes exceeding 20 meters in height, found at 750 to 900 meters elevation in Perak, Malay Peninsula. The leaves are elliptic, acute, thinly coriaceous, and 16 to 38 cm. long, and up to 16 cm. wide. The flowers are pale yellow tinged with red, terminal, the female solitary. The fruit is roundish, flattened, 5 cm. long and 7.5 cm. in diameter, with many deep longitudinal grooves, pale rose to red, and edible It should be tried as a stock for the mangosteen.

G. cowa Rxb. Cowa

A handsome tree up to 18 meters tall, with slender drooping branches, from the Andamans and Bengal to Burma and Assam. The leaves are broadly lanceolate, acute, thick and shining, 7.5 to 12 cm. long. The flowers are terminal and axillary. The fruit is of the size of a small orange, roundish, depressed at the apex with a nipple-like projection in the center, and 4 to 8 longitudinal grooves, dark yellow, the pericarp fleshy and of good flavor like the pulp which contains 4 to 8 seeds. The fruit ripens in June and July, and is said to make a remarkably fine preserve.

G. cumingiana Pierre. MALABU

A small tree up to 10 meters high, found at low and medium elevations, in part in regions with a long dry season, in northern Luzon, Philippine Islands. The leaves are oblong or elliptic-oblong, acuminate, leathery, and up to 20 cm. long. The flowers are terminal, solitary, and yellow. The fruit is roundish, somewhat flattened, smooth, up to 5 cm. in diameter, fleshy, acid, and edible. The *Malabu* should be tried as a stock for the mangosteen.

G. delpyana Pierre. TRAMENG

A tree 10 to 18 meters tall, native of Indo-China. The leaves are oblong to linear-oblong or lanceolate, leathery, and 10 to 20 cm. long. The male flowers are terminal or axillary, the hermaphrodite solitary. The fruit is globose, about 3 cm. in diameter, smooth, yellowish, and has a spongy pericarp. The pulp in which the seeds are embedded is of pleasant taste, and divided into 6 to 7 locules. The *Trameng* should be tried as a stock for the mangosteen.

G. dioica Bl. TJEURI

A very characteristic tree up to 18 meters high, with erect trunk and spreading branches, found throughout Java below an altitude of 1,200 meters, common in many districts but nowhere cultivated. The leaves are rather small, oval to lanceolate, acuminate and thin. The flowers are terminal and axillary. The fruit is subglobose, somewhat flattened, depressed at apex, up to 3.5 cm. long, and up to 4 cm. in diameter, pale yellow, the pulp 6- to 10-loculed, and of refreshing flavor. In foliage and habit the tree does not appear to be closely related to the mangosteen, but the fruit is said to be similar to it and its trial as a stock might be worth the while.

G. dives Pierre. PILDIS

A small slender tree, 10 or more meters tall, of wide distribution under widely varying climatic conditions at low and medium elevations in the Philippines. The leaves are rather small, elliptic-lanceolate and pointed. The flowers are produced in the axils of the leaves. The fruit is roundish, 2 cm. in diameter, fleshy and edible.

G. dulcis Kz. BANITI (P. I.), MUNDU (Malay)

A small tree 9 to 15 meters high, of wide distribution at low and medium elevations succeeding well even where the dry season is pronounced, native of the Philippines, Burma, the Malay Peninsula and Archipelago. Cultivated in Java, and recently domesticated in the Philippines. The leaves are oval to elliptic and oblong, thick and leathery, 12 to 20 or more cm. long. The flowers are axillary. The fruit is 5 to 7 cm. in diameter, in shape resembling a small pointed peach, smooth and yellow, the pericarp fleshy and edible like the juicy pulp in which 2, rarely 3 seeds resembling large beans are embedded. Both the pericarp and the arils are quite acid, but tender in texture and of pleasant flavor, and make excellent jam. Trees with subacid fruits occur now and then.

G. fusca Pierre. Bua Lunur

A shrubby tree 5 to 8 meters high, found in Indo-China. The leaves are oval to linear-oblong, leathery, 8 to 15 cm. long. The flowers are axillary. The fruit is roundish to ovoid, with a pointed apex, smooth, fleshy, acid and edible, ripening in October.

G. globulosa Ridl. Kandis

An erect tree 18 or more meters tall, common in the forest in the Straits Settlements. The leaves are elliptic, acuminate, 5 to 7.5 cm. long. The flowers are terminal and axillary. The fruit is round, 1.3 cm. in diameter, orange-colored, pulpy, and of pleasant flavor. The tree is abundantly productive.

G. griffithii T. And. Sibangor (Sum.) Kandis Gajah (Mal.)

A large, rather common tree 15 to 18 or more meters tall, found in Sumatra and the Malay Peninsula below 300 meters elevation. The leaves are remarkably large, up to 45 or more cm. long and 18 cm. wide, ovate or ovate-elliptic, obtuse, leathery and shining. The flowers are axillary. The fruit is 5 to 7.5 cm. in diameter, pomiform, flattened at apex, greenish yellow, juicy, acid and edible.

G. harmandii Pierre Remir

A low-branched tree of compact growth 6 to 10 meters high, native of Indo-China. The leaves are obovate and leathery, 4 to 10 cm. long. The flowers are terminal, the female solitary. The fruit is subglobose, flattened, up to 2 cm. across, purplish, the pulp sweet and of pleasant flavor, containing 1 to 3 seeds. The fruit ripens in April. Pierre, speaking of the eating quality of the fruit, suggests that it merits the attention of horticulturists. The tree should also be tried as a stock for the mangosteen.

G. hombroniana Pierre Bruas, Mangin Hutan

A tree resembling the mangosteen, 9 to 18 meters tall, wild or planted at low elevations in the Nicobar Islands and the Malay

Peninsula, particularly mentioned as growing in sandy soil near the sea. The leaves are ovate-elliptic to ovate-oblong, short acuminate, somewhat glossy above, 9 to 15 cm. long, and 5 to 7 cm. wide. The flowers are dioecious, terminal, cream colored, and smaller than in the mangosteen. The fruit is similar in shape to the mangosteen but smaller, 5 cm. in diameter, the pericarp red, crustaceous and fibrous, but thinner than in the mangosteen, the 6-loculed pulp white, juicy and acid, and said to have the flavor of the peach. Ridley was so impressed with the quality of the *Bruas* that in an article published already in 1902 he said that it "would very much improve the common mangosteen if it could be crossed with it." Though it would seem improbable that the quality of the mangosteen could be improved by crossing it with another plant admittedly its inferior, nevertheless, the hybridization of the mangosteen and this and other of its more vigorous relatives with a view of producing hybrids of greater vigor than this fruit cannot be urged too strongly. New flavor combinations would be obtained in this way, and hybrids might also be produced that would prove serviceable stocks. Altogether, it is a fascinating problem. Being so closely related to the mangosteen, undoubtedly this tree could be easily grafted on the *Bruas*.

G. indica Cy. KOKAM, KATAMBI

A small slender tree with drooping branches, native of western India, cultivated around Bombay and in Mauritius; also introduced into the West Indies, including Porto Rico. The leaves are elliptic-lanceolate, acute to acuminate, thin, dark green, 7 to 10 cm. long. The male flowers are terminal and axillary, the hermaphrodite are solitary and grow at the ends of the twigs. The fruit is roundish, from 4 to 5 cm. in diameter, and purplish like the acid but agreeably flavored pulp which is divided into 4 to 8 locules. An edible fat is extracted from the seeds. The fruit ripens in the spring. The plant is sufficiently closely related to the mangosteen to deserve a trial as a stock.

G. kerstingii Engl.

An arborescent shrub to a small tree, found from sea-level up to an elevation of 500 meters in Togoland and Guinea. The leaves are oblong-lanceolate to elliptic-lanceolate, leathery, 10 to 15 cm. long. The fruit is globose, 1.5 cm. in diameter, yellowish to pinkish, 2-seeded, and is eaten by the natives. It ripens over a large part of the year.

G. lanceofolia Rxb. KIRINDUR

A small tree native of Burma and Assam, in the latter country cultivated for the fruit which is much esteemed by the native inhabitants. The leaves are narrow lanceolate, acute, 8 to 9 cm. long. The flowers are axillary or terminal, the female solitary. The fruit is about the size of a small plum, obovoid, orange-yellow, containing 6 to 8 seeds. It ripens in July.

G. lateriflora Bl. DJAWURA (Java), KARIIS (P. I.)

A slender tree up to 15 meters high, of wide distribution from sea-level up to 800 meters altitude in the Philippines, in central and western Java up to 1,000 meters. The leaves are elliptic to elliptic-lanceolate, acuminate, thin, 10 to 24 cm. long, and 5 to 8 cm. wide. The flowers are axillary. The fruit is subglobose, flattened, 2.5 to 3.5 cm. in diameter. In the Philippines the pulp is juicy, acid, and of pleasant flavor. In Java the fruit is reported to be sweet and commonly eaten, and Koorders and Valeton commend it to the attention of horticulturists. It ripens in December.

G. livingstonei T. And. PAMA, IMBE, MOKONONGA

A shrub to a small tree, native of tropical Africa. The leaves are opposite or ternate, broadly elliptical or obovate-elliptic, blunt or notched, up to 9 cm. long. The flowers are axillary. The fruit is oblong, up to 5 cm. long, red or purplish, the pericarp fleshy, juicy edible, and together with the pulp used in making a fermented liquor by the natives. Seeds 2 to 3. The *Pama* has been successfully introduced and fruited in south Florida.

G. loureiri Pierre. BUANHA

A tree 10 to 15 meters tall, native of Indo-China where sometimes it is cultivated. The leaves are oval-oblong or oblong-lanceolate, leathery, 8 to 12 cm. long. The flowers are axillary or terminal. The fruit is short oblong, 5 cm. long, and 4 cm. in diameter, grooved corresponding to the locules which vary from 6 to 10. The pericarp is yellow on the surface and reddish inside. The pulp is white, acid and of agreeable taste. In preparing it for storage the pericarp is sliced, dried and salted, and then prepared for food, or used for flavoring in place of vinegar. The fruit ripens in June.

G. macrophylla Miq. SELAPAN

A tree 20 to 30 meters high, native of Sumatra. The leaves are large, oval to elliptic, acute to blunt, 33 to 38 cm. long, and 15 to

19 cm. broad. The flowers are axillary. The fruit is pomiform, 4-loculed, acid, and eaten by the natives.

G. mangostana L. MANGOSTEEN

A small tree rarely more than 9 meters in height, believed to be native of the Malay Archipelago or Peninsula. The leaves are oblong-elliptic, acuminate, thick and leathery, shining above, 17 to 23 cm. long. The flowers are terminal, red, the female solitary or in pairs, 5 cm. in diameter. The fruit is about 6 cm. in diameter, globose, a trifle flattened, smooth, reddish or purplish. The snow-white, exquisitely flavored, subacid pulp is divided into 5 to 8 locules, enclosed in a crustaceous, fibrous, shell-like pericarp about 8 mm. thick. The mangosteen is unexcelled as a dessert fruit, and makes a delicious preserve boiled (including the seeds) with sugar. On its own roots the mangosteen thrives only on the lowlands, perhaps up to an altitude of about 600 meters, where the rainfall is fairly ample and well distributed throughout the year. If the hopes are realized relative to the use for stocks of the Bunag and perhaps other species, the culture of the mangosteen might be extended over a great part of the Tropics. Definite information at what age seedling trees come into bearing is lacking. Some authors claim that they bear at the age of 7 to 10 years, while others say that 15 to 20 years' growth is required before fruiting. Certainly the growth of young plants is very slow, and under the most favorable circumstances they probably do not bear until 8 to 10 years old. A full-grown tree will bear from 200 to 500 fruits, and maximum crops of 1,200 fruits have been reported. Two crops per annum are not uncommon.

G. merguensis Wight. LULAI (Malay), SONVE (Annam)

An ornamental tree up to 15 or more meters high, from Burma and the Malay Peninsula to Indo-China, where it occurs from sea level to an altitude of 1,400 meters. The leaves are lanceolate-elliptic to ovate, acuminate, thinly coriaceous, 5 to 10 cm. long. The flowers are axillary. The fruit is roundish, somewhat flattened, up to 2 cm. in diameter, and has a fleshy pericarp. The fruit is eaten in Indo-China.

G. mestoni F. M. B.

A small, erect, slender, graceful tree 7 or more meters tall with drooping branches, found in Queensland. The leaves are narrow lanceolate, undulate, dark green and glossy, 5 to 10 cm. long. The fruit is globose, flattened, 5 to 7.5 cm. in diameter, green, smooth, the pericarp fleshy, and together with the juicy, 8-celled pulp of pleasantly acid flavor.

mindanaensis M. KABANGLA

A small, slender tree attaining a height of about 10 meters, found medium altitudes in Mindanao, Philippines. The leaves are 12 18 cm. long, and 4 to 8 cm. wide, pointed. The red flowers are rne in the axils of the leaves. The fruit is up to 3 cm. in diameter, ooth, acid and edible.

nigro-lineata Pl. KANDIS (Malay)

A slender tree 10 to 14 meters tall, native of Malaya, Burma d Siam. The leaves are lanceolate or ovate-lanceolate, somewhat thery, russet colored beneath, 12 to 20 cm. long. The flowers are xillary. The fruit is ovoid, about 3.5 cm. long, orange yellow, and s a soft, fleshy, acid, pericarp, and sweet pulp of pleasant flavor. e tree is abundantly prolific.

oliveri Pierre. TROMENG

One of the largest trees in the genus, 20 or more meters tall, ative of Indo-China. The leaves are 10 to 27 cm. long and 4 to 8 n. wide, and pointed. The flowers are axillary or terminal. The uit is short oblong, compressed at both ends, 4 to 5 cm. long, and to 4 cm. in diameter, smooth, reddish, the pericarp fleshy, and gether with the 9- to 10-celled pulp very acid, but nevertheless uite sought for as a food by the natives. The fruit is common in he market from June to September, and is sliced and preserved with alt.

paniculata Rxb. BUBI-KOWA

A tree about 13 meters high, found in Bengal and the foot hills the eastern Himalayas, ascending to 1,350 meters. The leaves are blong-lanceolate to obovate, acuminate, thin, shining, 15 to 23 cm. ng. The flowers are terminal. The fruit is about the size of a arge cherry, round, yellow, the pulp of good flavor resembling somewhat the mangosteen, containing 4 seeds. The fruit ripens in July. The plant should be tried as stock for the mangosteen.

G. *parvifolia* Miq. KANDIS

A tree of upright growth and slender branches 12 to 15 meters tall, native of the lowlands of Sumatra and Singapore. The leaves re elliptic to oblong-lanceolate, acuminate, dark green, thinly coriaous, 6 to 14 cm. long. The flowers are axillary. The fruit is of the size of a cherry, elliptic, orange yellow, fleshy and acid, and is eaten by the natives in Sumatra. One to 3 seeded.

G. pedunculata Rxb. TIKUL

A stately tree of rapid growth attaining a height of 20 meters, native of Bengal and Sylhet. The leaves are quite large, oblong to elliptic-oblong, somewhat leathery, 28 to 40 cm. long, and 10 to more than 13 cm. wide. The flowers are terminal. The fruit is subglobose, sometimes more than 10 cm. in diameter, yellow, the fleshy pericarp sometimes more than 2 cm. thick, and like the juicy, 8- to 10-loculed pulp very acid but of pleasant flavor. The tree is cultivated, and the fruit is used in curries and for making "ades". Sliced and dried the fruit keeps in good condition for a long time. The fruit ripens from April to June. The *Tikul* deserves a trial as a mangosteen stock.

G. planchoni Pierre.

A tree 15 to 20 meters high, native of Indo-China. The leaves are oblong to oblong-elliptic or obovate, 18 to 24 cm. long, with prominent lateral veins. The flowers are terminal or axillary. The fruit is roundish, grooved lengthwise, with a few wart-like protuberances on the surface, 7 to 8 cm. in diameter, greenish yellow. The pericarp is quite thick, fleshy, acid, and like the acid, 8-celled pulp, edible and of agreeable flavor. The fruit ripens over a large part of the year. The natives slice and dry the fruits in the sun with or without salt, which so conserved keep a long time. Pierre remarks that the fruit merits cultivation.

G. prainiana King. CHERAPU

A small tree about 9 meters high, native of the Malay Peninsula. The leaves are elliptic-oblong, leathery, dark green, shining, 12 to 22 cm. long. The flowers are terminal. The fruit is subglobose, flattened, up to 5 cm. in diameter, yellow and smooth, with a fleshy acid pericarp, and subacid edible pulp. According to Ridley the Cherapu is eaten like the mangosteen, for which the plant deserves a trial as stock.

G. rubra M. KAMANI

A small tree attaining a height of 10 meters, found at low elevations from northern Luzon to Mindanao, Philippine Islands. The leaves are elliptic to elliptic-obovate, acute to acuminate, thin, and 6 to 12 cm. long. The flowers are axillary and bright red. The fruit is subrotund, flattened, up to 3 cm. in diameter, smooth, yellowish to red, fleshy, acid and edible.

G. subelliptica M. DANGALAN

A tree 10 to 15 meters high, found in eastern Luzon immediately back of the beach. The leaves are broadly elliptical with rounded ends, thick and leathery, about 10 cm. long. The flowers are white, and borne in the leaf axils. The fruit is subrotund, flattened, 5 cm. in diameter, yellow, fleshy, acid and edible, containing 3 or more large seeds.

G. tetranda Pierre. TAMIL

A small tree found at low and medium altitudes from southern Luzon, through Samar and Leyte to Mindanao. The leaves are 12 to 15 cm. long, pointed or rounded at the ends, and rather thin. The small axillary flowers are followed by roundish, flattened fruits, 3 to 4 cm. in diameter, yellowish to reddish, smooth, with scant, sour but edible pulp.

G. tinctoria W. F. Wight. MATAU

A symmetrical tree up to 15 or more meters high, native of India to the Malay Peninsula and the Andamans. Introduced in Porto Rico where it has fruited well. The leaves are quite large, linear-oblong to oblanceolate, acute or acuminate, leathery, dark green and shining, 20 to 45 cm. long, and up to 10 cm. wide. The flowers are axillary. The fruit is 5 to 7 cm. in diameter, roundish and pointed at the apex in the manner of a peach, smooth, bright yellow, very acid but of pleasant flavor, containing 1 to 3 large seeds. The tree is robust, and of rapid growth, and is very productive, sometimes yielding two crops per year. The fruit is a good keeper.

G. venulosa Cy. KATURY

A tree attaining a height of about 15 meters, of wide distribution at low and medium elevations in the Philippines, thriving also in districts with a prolonged dry season. The leaves are oblong, acuminate, leathery, 20 cm. or more in length. The flowers are small, axillary or terminal. The fruit is 4 to 6 cm. in diameter, subrotund, somewhat flattened, smooth, greenish, with acid flesh, eaten with fish by the Filipinos.

G. vidalii M. KANUBI

A tree up to 15 meters high, found in regions with a well-distributed rainfall at low and medium altitudes, from northern Luzon to

Mindanao. Seldom cultivated. The leaves are broadly oval, dark green, glossy, thick and leathery, 10 to 20 cm. long. The flowers are white, and grow at the ends of the twigs. In appearance the fruit somewhat resembles the mangosteen, but has a fleshy, acid pericarp, is yellowish in color, and has acid edible flesh, enclosing 10 or more seeds. It should be tried as a stock for the mangosteen.

G. wentzeliana Engl. Mdogolo

A stout, woody climbing vine, native of tropical Africa. The leaves are oblong to obovate-oblong, leathery, shining, 10 cm. long, and up to about 5 cm. wide. The fruit is roundish, about 1.5 cm. in diameter, sweet, juicy and of agreeable flavor. It ripens in January.

G. gerrardi Harv. Umbindi

A large shrub or a small tree about 4 meters tall, found from Cape Colony to Natal and Zululand. The leaves are broadly lanceolate, oval or elliptic, acute, glossy above, 2.5 to 5 cm. long. The flowers are terminal. The fruit is roundish to ovoid, up to 2 cm. long, black, with edible flesh, one-seeded. The fruit is produced sparingly. The Umbindi, which probably is quite frost-resistant, should be tried as a stock for the mangosteen.

G. barrettiana n. sp. Kadis

A small tree 5 or more meters tall with slender branches, found in the Cotabato valley, Mindanao. The leaves are rather small, thin and pointed, 7 to 10 cm. or more long. The fruit grows in the axils of the leaves, and is up to 6 cm. in diameter, markedly oblate, with a shallow cavity at apex; the surface smooth, light orange in color; the pericarp soft, fleshy, acid, and edibe; the pulp surrounding the seeds light orange in color, juicy, subacid, and of good flavor, divided into 6 to 8 locules, the seeds quite similar to those of the mangosteen. The fruit ripens in December and January, and can be eaten out of the hand with relish, but probably could be best utilized made into preserves like the mangosteen. Abundantly productive.

G. mooreana n. sp. Bunag

A handsome tree of pyramidal habit attaining a height 6 meters or more, native of Jolo and Palawan, in which latter island it is found about Iwahig, where it is known as *Bunag*. The leaves are elliptic to elliptic-ovate, or ovate-oblong, acute at base, acute to short acuminate at apex, coriaceous, 15 to 21 cm. long, 7.5 to 11 cm. wide, the petiole about 15 mm. long. The fruit is similar to a mangosteen, except that it is somewhat smaller, is red in color, and has a thinner, but fibrous, crustaceous pericarp; the flesh is white and sharply acid, of agreeable flavor, but too sour to be eaten out of the hand. It would probably make a good preserve boiled together with the seeds in sugar. Ripens in the latter part of July and August. As previously noted the mangosteen has been successfully grafted on the Bunag.

GARCINIAS AS ORNAMENTALS

Like the mangosteen, many species of *Garcinia* are very handsome trees, and can be used to great advantage for decorative plantings in parks and gardens. The best oramental species is perhaps *Garcinia andersonii* Hook. f., with its large leaves, 30 to 60 cm. long, and up to 22 cm. broad, and large pomiform fruits, which is described as "by far the noblest species in the genus". It is a native of Malacca.

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